

RESEARCH IN ADVANCED CONCEPTS IN  
BIOTECHNOLOGY, HUMAN ANALOGS AND BIONICS

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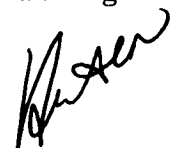
## ABSTRACT

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This report describes the human analog of the visual sensor. Analysis of the operation of the human eye was conducted utilizing the framework of the Man-Machine Methodology. In order to provide a familiarity with the terms used in the analysis, an outline of the physiology and anatomy of the eye is presented. Also an outline of the photoreceptor processes is given.

It was found that the human analog provided a penetrating insight into the fundamental mechanisms and processes carried out in the eye. Where gaps in the assembled data were located, basic research projects were suggested. Machine extenders could be directly developed from the human analog. Further scientific investigations in the format of the human analog may be expected to produce a deeper understanding of the fundamental operation of the human body.

Information presented in this report can be directly applied to the design of visual machine extenders that operate on the same principles as the human eye. One advantage that such a bionic device would have is that it could operate over a narrow frequency range after detecting impinging radiation. New and efficient devices that function in the visible, infra-red, ultra-violet or, in fact, in any portion of the electromagnetic spectrum could be build that utilize the fundamental ideas presented in this report on the human analog of the eye.



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## INTRODUCTION

This is the first quarterly report for NASA Contract NASw-780, Research in Advanced Concepts in Biotechnology, Human Analogs and Bionics, covering the period from 8 July 1963 to 8 October 1963. In this report, Teledyne Systems Corporation has concentrated on Task One-a and Task Two-1 of the contract.

The objectives of the effort which is described in this report are the following:

### Task One

Conduct advanced research in the field of Human Analogs. This will include analyses to define selected basic human body systems in terms of mathematical models compatible with computer techniques so as to establish the fundamental interface relationships between Man and Machine for Advanced Space Applications. Systems Analysis Methodology which was developed for the Director of Biotechnology and Human Research under NASA Contract NASw-567 will be used in conducting the proposed advanced research in Human Analogs. Mathematical models will be established for the matrices pertinent to the selected human body systems, and for the related machine functions.

The manipulation of the Man and Machine models in the Systems Analysis matrices will establish:

- a. The Human Analogs for the selected human body systems.

### Task II-1

This task shall be conducted as follows:

1. Examine the selected physiological functions to establish the fundamental mechanisms and processes.

Research in Advanced Concepts in Biotechnology, Human Analogs and Bionics began with a review of the literature concerned with the physiology of man. The human body was studied with emphasis on those subsystems that handle information. Study was directed toward examining how man inputs, distributes and controls and outputs information. These three categories were used to classify the subsystems of man. This breakdown is shown in Table I.

Input	Distribution and Control	Output
Visual	Nervous	Musculo-Skeletal
Auditory	Endocrine	(Movement and speech)
Gustatory	Small Intestine (Digestion)	Skin (Sweat, flakes and Thermal)
Olfactory	Cardiovascular	Excretory
Tactile		Reproductive
Radiation		
Respiration		
Upper G.I. Tract (Entering food for digestion)		

Subsystems of Man  
Table I.

From Table I, one subsystem from each category was selected to be analyzed. The visual, nervous and musculo-skeletal subsystems were chosen. The major criteria used in selection was that each represented the subsystem of greatest apparent information flow when examining input, distribution and control, and output respectively. These three categories are basic to the Man-Machine Systems Methodology. The Methodology is summarized in Appendix A.

The visual sensor, which is an information input subsystem, is the subject of this report. An analysis of the operation of the human eye will be conducted for a number of reasons. First, the analysis will produce the Human Analog of the visual sensor. In assembling the data within the framework of the Man-Machine Systems Methodology, areas where physiological investigation is lacking will be found. Finally, the analysis will be used as the basis upon which to determine extensions of the visual sensor.

## HUMAN ANALOGS

It is quite important that the meaning of a Human Analog be established for purposes of this report and also to distinguish between it and a Machine Analog. It is perhaps most easily done by using an illustration from a field that has made use of analogs for the purpose of study. Such a field is found in the realm of mechanics. Springs, masses and vibratory systems are for the most part describable by sets of differential equations. These equations constitute a symbolic representation of the mechanical system which they describe. Quantities vary in the equations in a manner which is analogous to the positions and velocities of different parts of the mechanical system; thus, the proper set of differential equations are said to be a mathematical analog of the mechanical system.

It is possible to consider other systems that can be symbolized in an identical mathematical form. For example, electrical circuit components give rise to mathematical models that are similar in form to the mechanical systems. It is this fact that allows a collection of particular circuit elements (i.e., an analog computer) to perform in a functional fashion that is identical to the mechanical system. Currents and voltages are seen to be analogous to positions and velocities. Once the analogous properties have been established, it becomes a simple matter to combine elements from analogous systems. Thus, a guided missile, which is basically a mechanical structure, utilizes electrical amplifiers and filters to control its kinematic behavior.

The human analog is the symbolic representation of a human biological function. It has already been established in the newly developing field of bionics that as human analogs become established, improved machine analogs (extenders) can be specified. Just as in the case of the guided missile, a combination of analogous systems is utilized. It should also be possible to relate man and his machine extenders so that they operate in a perfect union of analogous systems. The cardiac pacer is one excellent example of what this union can mean to man even in rudimentary form.

The first step then is to establish a symbolic analog or human analog. Unfortunately there are no sets of differential equations that describe the functioning of man's interrelated systems as apply to the field of mechanics. On the other hand, equations are merely a convenient way of relating variables. This data can also be viewed in a tabular form, and, in fact, most highly non linear problems are approached in precisely this manner. Relationships are established and are analyzed by digital data processing equipments. These equipments in turn allow the investigator to predict the behavior of the system under variable input conditions. Problems of tabulation and retrieval of information have been dealt with by Teledyne Systems Corporation under Contract NASw-567. The Methodology developed under this contract provides the basis for the establishment of the human analog.

Teledyne Systems Corporation chose the human analog of man's visual sensor as its first application of the Methodology. Information had to be extracted from the literature and set up in the symbolic format of the Methodology. When the literature lacked necessary information, a hypothesis was formed to act as a bridge between existing areas of knowledge concerning the basic principles by which the eye operates.

It was found in the course of assembling this information that many physiological and physical principles were revealed to apply to the operation of the eye, i. e. , cellular division of work, field partical-interaction, photochemistry, etc. Thus, to fully understand the eye and its operation requires a full understanding of exactly what goes on in any photochemical reaction.

A final question should be raised before going to the specific subject material of this report, that is, of what benefit to NASA is the establishment of human analogs and machine analogs?

Human analog studies are necessary to the successful execution of any space mission from the following standpoints:

1. Prediction of survival of the human engaged in performing a space mission depends upon formulating human responses to hostile environments. The human analog is a predictive model.
2. In environmental simulation studies, parameters to be measured must be specified bascd upon their value in predicting consequences of temporary extremes. The human analog establishes the essential parameters.
3. To extend man's capabilities it is essential that the manner in which he functions is understood so that instruments, machines and vehicles can be designed that will efficiently enhance and extend man's known faculties. Human analogs indicate the requirements for machine analogs.

## SUMMARY OF FINDINGS

Scientific investigation following the format of the Man-Machine Methodology to establish the human analog of the eye was found to be an excellent method to explain the fundamental mechanisms and processes carried out in the visual sensor. Many advantages were realized by developing the human analog. Information contained in the analog can be understood by workers in all branches of research since the Methodology terminology has application to every field of science. Areas where basic research could produce major new concepts into the visual process were found. Studies of how the eye detects visible radiation and how the visual sensor operates to determine color were found to be two of these areas. Tracing the information signal through the eye was an effective way to uncover the visual processes. Focusing on the flow of the information signal was suggested as a guide to scientific investigations that are studying functional operation. The human analog can be directly applied to the design of machine extenders to aid the eye. There are many areas of scientific endeavor that can benefit from the research that has been conducted to establish the visual human analog.

SUBSYSTEM LEVEL EXAMINATION OF  
THE OPERATION OF THE HUMAN EYE

## OUTLINE OF THE PHYSIOLOGY AND ANATOMY OF THE EYE

Before beginning to apply the Methodology, a review of the physiology of the eye was made. The purpose of this study was to gather the facts that would be assembled according to the framework of the Methodology.

In performing an examination of the physiology of the eye it is necessary to describe the boundaries of this subsystem. Five-sixths of the eye is bounded by the sclera, which is white and opaque. From the front of the eye, a portion of the sclera may be seen as the white of the eye. The sclera is composed of a tough inelastic fibrous material that forms the protective exterior coat of the eye. This coat maintains the shape of the eye and gives it an almost spherical form. An average eye can be contained within a one-inch sphere. The remaining one-sixth sphere not covered by the sclera is protected by the cornea.

Anteriorly (toward the front of the skull) the eye is bounded by the cornea. This coating is made of material that is very similar to that found in the sclera, but in the cornea the fibers are transparent to a specific band of electromagnetic radiation (203 m $\mu$  to at least 3000 m $\mu$ ,<sup>1</sup> 1 m $\mu$  =  $10^{-9}$  meter). Thus the cornea acts as a frequency filter.

The cornea is also one of the components in the eye that refracts light and thus brings it to focus on the retina. The normal eye has a focusing power of 60 diopters. A diopter is the reciprocal of the focal length in meters. Focusing power is directly proportional to the differential in refractive indices between media. Air has a refractive index of 1.000

while the entire eye can be considered to have an index of 1.33 which is the same index as water. Comparatively there is a large differential in refractive index between air (1.000) and the cornea (1.376). This large difference means that the air-cornea interface has the greatest refractive power found in the eye. In fact, the cornea contributes about 40 diopters of the total power of the eye.<sup>2</sup>

Less bending of light takes place at the cornea-aqueous humor interface since the refractive index differential is small (1.376 for cornea and 1.336 for aqueous humor). The aqueous is 99% water containing dissolved salts. Composition of this fluid is quite similar in most respects to blood plasma and to the vitreous humor.<sup>3</sup> Sometimes the entire aqueous humor is called the anterior chamber (as opposed to vitreous body which is posterior), but this name can be confusing since the liquid is anatomically separated into two areas that are called the posterior and anterior chambers. These chambers are divided by the iris.

Physiologically the iris controls the amount of light entering the eye. Control is conducted by regulating the diameter of the pupil. The muscle that regulates this diameter is directed by information received in the retina since there are no light receptors in the iris.

Immediately posterior to the pupil of the iris is the lens (refractive index 1.4). The function of the lens is to focus entering light on the retina. As in the iris, the lens has no light receptors that can detect the focus of

light on the retina. Thus the signals to control the muscles of the lens must originate from the retina. These muscles change the curvature of the lens and therefore influence the refraction of light rays.

Light that leaves the lens is transmitted through the vitreous body. This body contains a transparent gel that is called the vitreous humor and is similar to raw egg white. Chemically the vitreous and aqueous are similar. Both have approximately the refractive index of water and both apply pressure to their surroundings.

In the posterior direction, the vitreous humor exerts pressure on the retina. The retina may best be viewed as a location for many components of the eye and not as a functional unit. This lining is not completely transparent because light must traverse the 0.1 mm thickness of the retina to be absorbed in the posterior surface.<sup>4</sup> Light that is not taken in by the retina strikes the choroid.

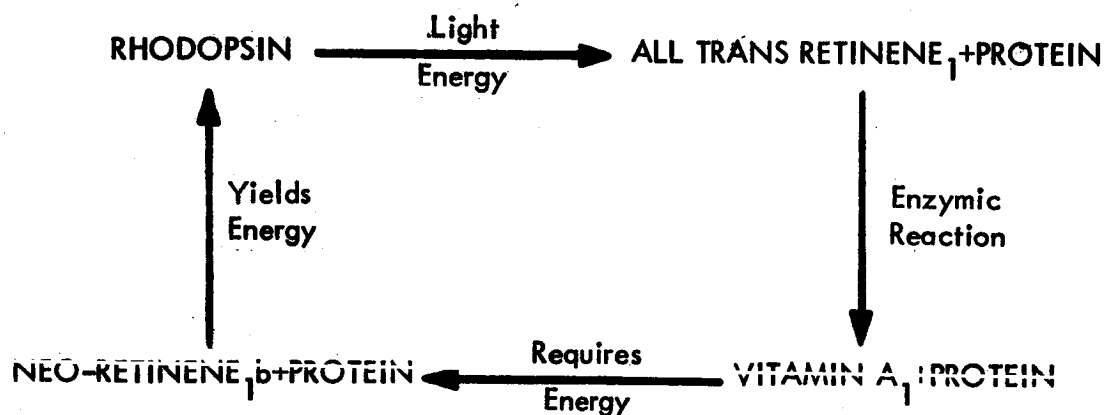
Functionally the choroid acts to absorb all incident rays so that no reflected light is allowed to stimulate the receptors. For this purpose, the choroid is black. The choroid lines the entire posterior half of the eye except where pierced by the optic nerve. This lining is in contact with the sclera in the posterior direction while anteriorly contact is made with the pigment epithelium layer of the retina.

Many dome-shaped cells compose the pigment epithelium. Near the cell boundaries a pigment called fuscine is concentrated. This pigment has an absorption band from 397 to 723 m $\mu$  which covers the visible range.<sup>5</sup> Throughout this range, the fuscine absorbs photons and transfers energy to

the photochemical substances in the light receptors that are in contact with the pigment epithelium. The two types of receptors in the eye are called rods and cones because of their respective shapes. Rods contain a photochemical called rhodopsin.

Rhodopsin is a very complex organic compound that has an atomic weight that is quoted as being from 46,000<sup>6</sup> to 270,000<sup>7</sup>. The two basic components of rhodopsin are retinene<sub>1</sub> and scotopsin (protein).

Initially the rhodopsin is dissociated into all-trans-retinene<sub>1</sub> and portein. (See Table 2).



#### RHODOPSIN CYCLE

TABLE 2

TSC 3345

The all-trans-retinene<sub>1</sub> is further reduced to vitamin A<sub>1</sub>. Energy is required to convert the vitamin A<sub>1</sub> to neo-retinene<sub>1</sub> b, but the recombination to form rhodopsin is spontaneous and yields energy. A short exposure of rhodopsin to instense light produces considerably more all-trans-retinene<sub>1</sub> than vitamin A<sub>1</sub>; during a long exposure to weak light, more

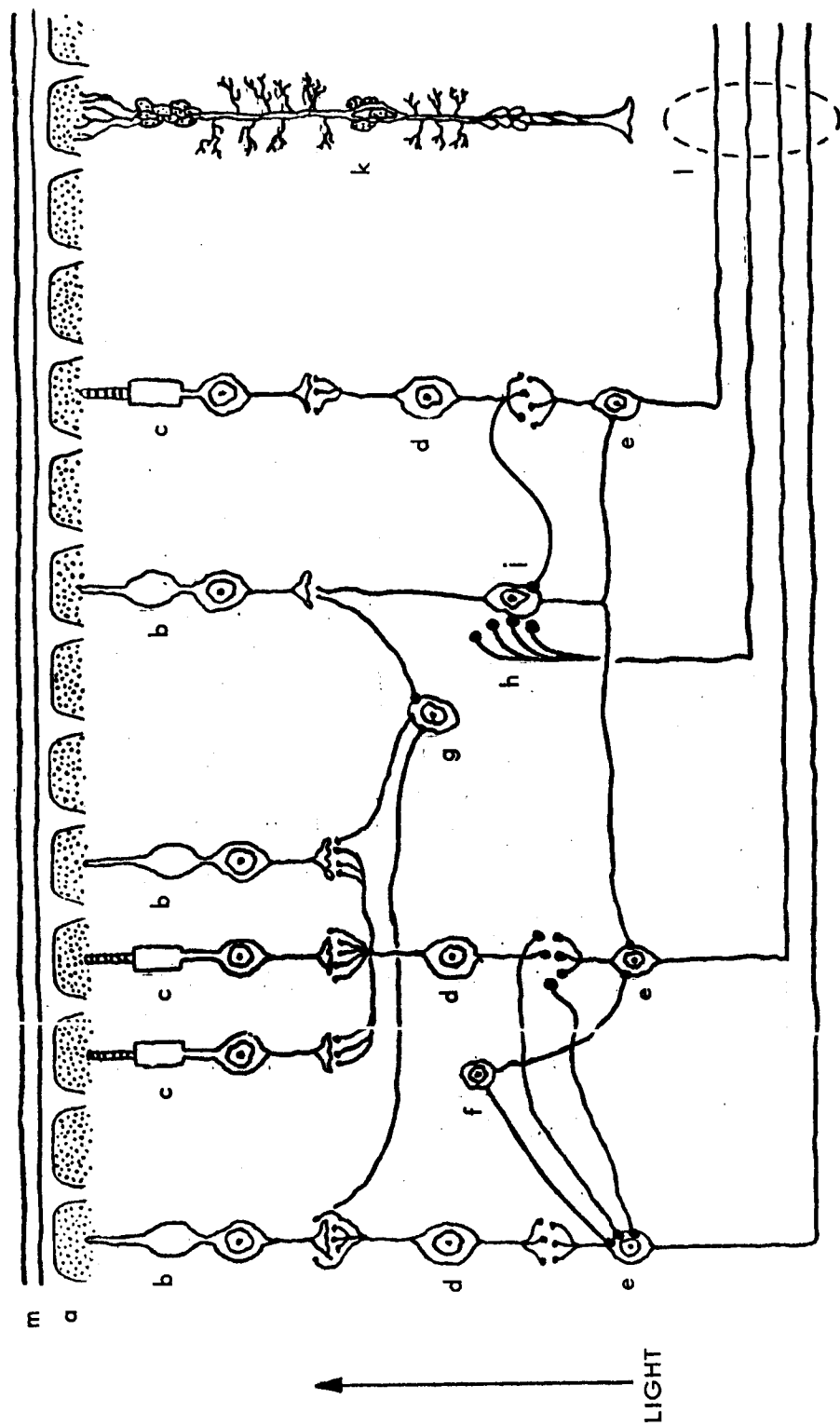
all-trans-retinene<sub>1</sub> is converted to vitamin A<sub>1</sub> shifting the equilibrium so that more vitamin A<sub>1</sub> is present.

Sometimes rhodopsin is called visual purple. When it is broken down, the color changes from purple to white. This bleaching is accompanied by a major deformation in the configuration of the protein scotopsin. As recombination of the protein and retinene<sub>1</sub> takes place, the original configuration of the protein must be restored. It is not clear if the retinene<sub>1</sub>-protein recombination or the readjustment in the configuration of the protein accounts for the excitation that rhodopsin produces.<sup>8</sup>

This explanation of the breakdown and resynthesis of rhodopsin deviates from the classical approach, but Table 2 indicates the hypothetical cycle derived from present research.

The photochemical rhodopsin is located in the rods and is broken down even in dim lights and thus makes night vision possible. Rods have another characteristic that makes them especially adept for seeing in little light. This characteristic is that frequently the effect of many rods are summed to stimulate one centripetal bipolar cell. Centripetal cells are sometimes referred to as the primary neurons, since they are the first cells to be stimulated by the receptors. See Figure 1.

Though rods give excellent night vision, in bright light all the rhodopsin breaks down simultaneously, and the receptors become ineffectual. Now the cones, which are the other type of light receptor, begin operating. Cones contain the photochemical iodopsin and are found throughout the retina. In the central portion of the retina, which is the



# THE RETINA

- |   |                    |   |                          |   |                          |   |              |
|---|--------------------|---|--------------------------|---|--------------------------|---|--------------|
| a | PIGMENT EPITHELIUM | d | CENTRIPETAL BIPOLAR CELL | g | HORIZONTAL CELL          | k | MULLER FIBER |
| b | CONE               | e | GANGLION CELL            | h | CENTRIFUGAL FIBER        | l | OPTIC NERVE  |
| c | ROD                | f | AMACRINE CELL            | i | CENTRIFUGAL BIPOLAR CELL | m | CHOROID      |

( SOURCE: J.D.SPOONER, OCULAR ANATOMY, p.45-1957 )

FIGURE 1

TSC 2219P

fovea (1500  $\mu$  in diameter)<sup>9</sup>, the cones are the only receptors. Generally one cone stimulates only one centripetal bipolar cell and thus gives more detailed and distinct vision than the rods because spacial integrity is maintained.

Centripetal bipolar cells stimulate the secondary neurons called ganglion cells. The axons of the ganglion cells comprise the optic nerve. Interconnections between receptors, centripetal bipolar cells and ganglion cells are made by association cells.

Association cells include the following: amacrine, centrifugal bipolar, horizontal and centrifugal fibers. Amacrine cells are in reversed position with respect to the rest of the retina since they face the ganglion cells. An association between ganglion cells and possibly the centripetal bipolar cells is provided by the amacrine cells. This association may be in either direction because amacrine cells are not bipolar and have no axons.<sup>10</sup> See Figure 1.

An association cell that has both axons and dendrites is the centrifugal bipolar cell which is closely related to the amacrine cell. Centrifugal cells receive impulses from centripetal bipolar cells, ganglion cells, and centrifugal fibers and transmit them to the receptors. Centrifugal fibers are derived via the optic nerve from the brain. It is possible that the brain sends inhibition and facilitation information to the neurons in the retina by means of the centrifugal fibers. Another type of association cell present in the retina is the horizontal cell that electrically ties the rods and cones together. Horizontal cells transmit electric pulses to receptors that are as far as 1 mm away. This distribution of pulses gives spacial induction.<sup>11</sup>

Beside association cells, there are neurogical cells in the retina. The major neurological cell is the Muller fiber that electrically insulates the neurons and holds them a controlled distance apart.

## References for Physiology and Anatomy of the Eye

1. Adler, Francis Heed, Physiology of the Eye, Third Edition, C. V. Mosby Company, St. Louis, 1959, p. 498
2. Spooner, J. D., Ocular Anatomy, The Hatten Press Ltd., London, 1957, p. 13
3. Adler, p. 237
4. Spooner, p. 41
5. Fulton, John F., A Textbook of Physiology, Seventeenth Edition, W. B. Saunders Co., Philadelphia and London, 1955, p. 446
6. Hartridge, Hamilton, Recent Advances in the Physiology of Vision, The Blakiston Company, Philadelphia, 1950, p. 345
7. Hartridge, p. 38
8. Adler, p. 522
9. Spooner, p. 13
10. Adler, p. 579
11. Spooner, p. 46

SUBSYSTEM LEVEL APPLICATION OF THE  
MAN-MACHINE SYSTEMS METHODOLOGY TO  
ANALYZE THE OPERATION OF THE HUMAN EYE

## ANALYSIS OF THE OPERATION OF THE HUMAN EYE

Prior to examining the analysis of the Operation of the Human Eye, it is strongly suggested that the reader, who is not familiar with the Man-Machine Systems Methodology, refer to the appendix where the overall procedure is explained.

In the analysis that follows, a number of files are presented that individually refer to a specific intersection on the Subsystem Matrix Charts (pages 25 and 34). Data is recorded on Environment, Function, Configuration and Material Information Sheets as well as on drawings. Preceding each file is a discussion of the steps taken to fillout the Information Sheets. Next is a Subsystem Matrix Chart that has the intersection under consideration blacked in. Intersections that have been previously examined are outlined. Following the chart are the Information Sheets themselves with the attendant drawings.

## Guide to Information Sheets

On beginning to apply the Methodology to the analysis of the operation of the human eye, the matrix charts were scanned to find the level that contained the visual sensor as an element. From the missions level, which is the most general, this scanning continued until the subsystem level matrix level chart was encountered. The Subsystem Matrix Charts are on pages 25 and 34. The subsystem level chart lists the eye under the column man, input, sensory, visual. In tracing this column down, all the influencing factors were encountered.

The first influencing factor that must be considered is environment. For the eye, the environment factor chosen for initial consideration was radiation, electromagnetic, visible. This is the intersection 4(subsystem level), 05(visible aspect), 01(man, input, sensory, visual column). For this intersection, a file was prepared that contained all the applicable information sheets. (Environment, Function, Configuration, and Materials).

On the Environment Information sheet, page 26, the parameters that were required to define radiation in the visible spectrum were stated. These parameters are frequency and intensity. It was felt that no meaningful entry could be made under the heading "amount of normal frequency" because visible light is rather uniformly distributed over the spectrum; consequently, the minimum and maximum frequencies define the range of visible light. For the parameter of intensity, the normal, minimum and maximum frequencies were found and listed on this information sheet.

Next, the supplementary information sheet of function, page 27 was filled out. The Methodology required that the entries on this sheet at the subsystem level be made with respect to the entire eye omitting reference to any of its components. The first column on this sheet asked for a statement of the functional aspect of the entire eye. To find this statement, the general aspects of function on the subsystem level matrix chart were scanned. Since the eye is a sensory subsystem that brings information to the nervous subsystem, the general aspect of input data was chosen to fill the first column.

In the second column, the object that directs visible radiation to the eye must be stated. The form of the energy that strikes the eye is a spacial relationship of light. This spacial relationship emanates from the object which is a visible image.

The following three columns on the function information sheet are labeled parameter, property and characteristic. These columns, that describe the object, supply unwanted details in the explanation of the general function of the entire eye at the subsystem level, and these spaces are blank.

Under the "convert to" column, a statement was made about what the output portion of the eye - the optic nerve - transmits to the nerves subsystem. This column contains the information that electric pulses are transmitted to the nervous subsystem. The next column asked for the method of conversion. Here the question first arises as to how the conversion from visible light to electric pulses takes place. This question cannot be answered at the subsystem level because a discussion of chemical

and atomic interactions is required. Thus only the general statement that light energy undergoes a conversion was made. A detailed analysis of the conversion will begin on the component level where chemical interactions can be discussed. The mechanism of conversion could not be stated at the subsystem level, but the operation was given. In observing the entire eye, the operation was seen to be the absorption of light energy.

The second supplementary sheet that was needed to describe the environment was the configuration form, page 28. In the first column of this form, there is space for the aspect. The subsystem level matrix chart lists the aspects of configuration. First the parts aspect was investigated in its relation to that portion of the human eye that was affected by visible radiation. For this aspect, each of the columns on the configuration information sheet was noted, and drawings were made to illustrate those areas that were pertinent to the environment influencing factor.

Under the column "Connection of Parts", the drawing called Components of the Eye in Visible Radiation Path, page 29, was called out. This drawing points out those parts of the eye that are affected by visible radiation. A portion of the retina is drawn in an inset. The inset shows those components that light impinges upon.

The column labeled "Environment Interface In" calls out drawing number 4-05-01-2. On this drawing there is a transverse section of the visual sensor. The boundary between the atmosphere and the eye is the outer membranous coating over the cornea. This is a liquid like layer that continuously cleanses the cornea. At this boundary, the eye first interacts with the visible radiation.

After the eye modifies the visible radiation, the information signal is transmitted to the nervous subsystem. The transmission takes place across the "Environment Interface Out", which is the next column on the configuration information sheet. Drawing 4-05-01-3 shows the interface out which is bounded by the optic nerve and the lateral geniculate bodies. These are the first neurons in the nervous subsystem to receive electric pulses from the eye. Each optic nerve fiber is related to five or six lateral geniculate neuron cells.

On this drawing, it will be noted that light must pass through a considerable portion of the retina before striking the photoreceptors (rods and cones). The light is filtered as it passes through the components of the retina. A question of function is posed by the configuration of the retina. Usually there is a reason for a specific placement of parts in nature. What is the purpose of the inverted retina? This question will be answered in the course of the analysis of the eye.

At this point, the next aspect of configuration was located on the subsystem matrix chart. The aspect is called support structure. For the eye the support structure is composed of the external muscles. Since there is no direct interaction of the support structure and the environment (visible radiation), this aspect was not considered further on the configuration information sheet. A similar situation exists for the configurational aspects called container, internal dynamics and external dynamics.

The final form encountered under the environment influencing factor was the Material Information sheet, page 32. On this sheet, a list of the components of the eye that are affected by visible radiation is required. The list was composed and included all of the parts that were illustrated on the drawing "Components of the Eye in Visible Radiation Path".

Four columns on the material information sheet are labeled: existence, availability, producibility and relative cost. These four terms relate to the synthesis of materials so they may be used in design. In the present case, an analysis of an existing subsystem (the eye) is being made, and thus consideration of these terms is not necessary.

[illegible]

## ENVIRONMENT INFORMATION

[illegible]

## FUNCTION INFORMATION

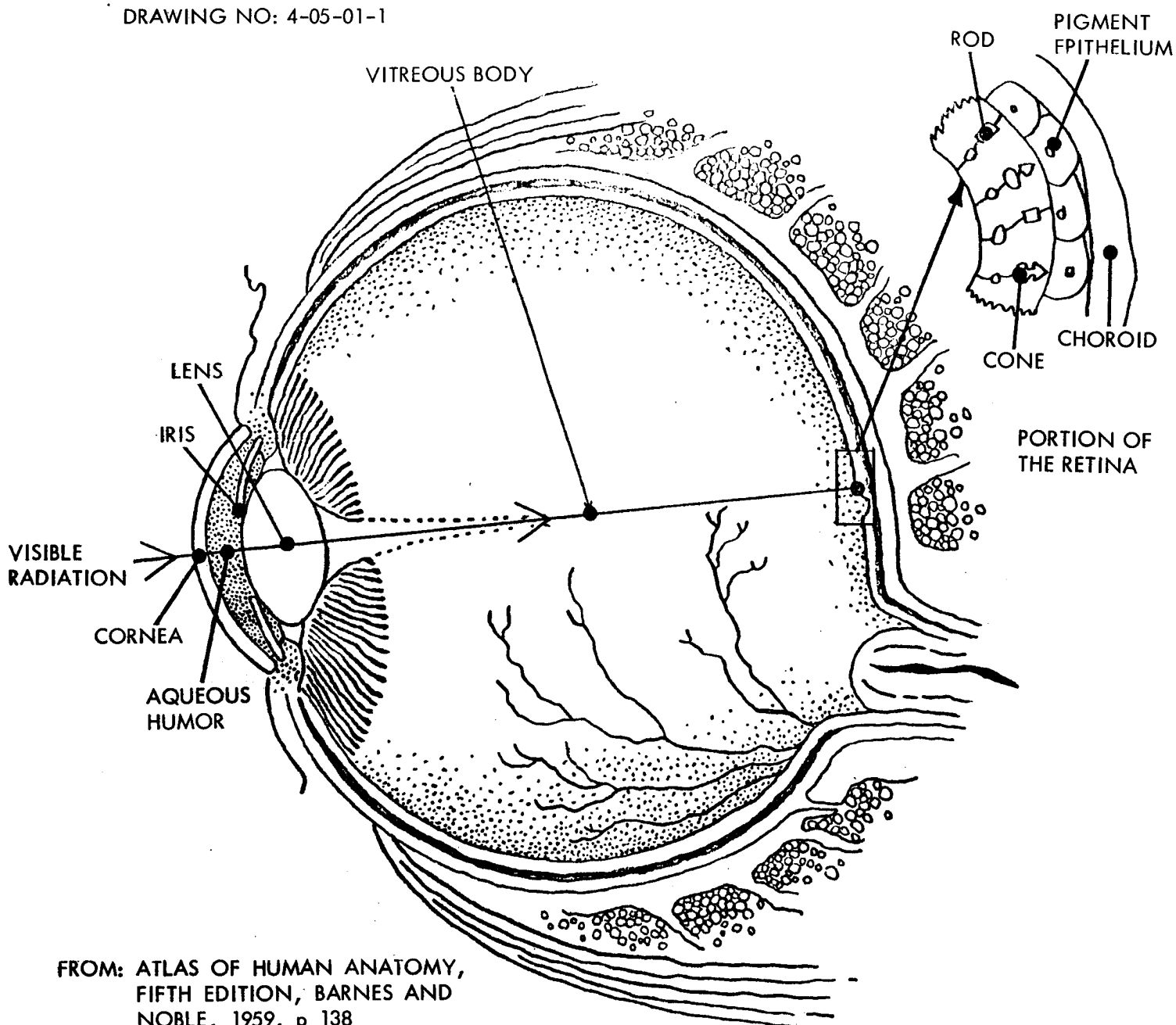
FILE NO: 4-05-01	ELEMENT: Man, Input, Sensory, Visual												
<div style="display: flex; justify-content: space-between;"> <div style="writing-mode: vertical-rl; transform: rotate(180deg);">DEFINITION</div> <div style="writing-mode: vertical-rl; transform: rotate(180deg);">FUNCTION</div> </div>	OBJECT	PARAMETER	PROPERTY	CHARACTERISTIC	CONVERT TO	METHOD	METHOD SUB-DETAIL NO.1	METHOD SUB-DETAIL NO.2	MECHANISM	OPERATION SUB-DETAIL NO.1	OPERATION SUB-DETAIL NO.2	CHANGE WHEN TOLERABLE LIMITS ARE EXCEEDED	
ASPECT: Input Data	visible image				electric pulses	conversion of light energy				absorption of light energy			

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## CONFIGURATION INFORMATION

[illegible]

DRAWING NO: 4-05-01-1



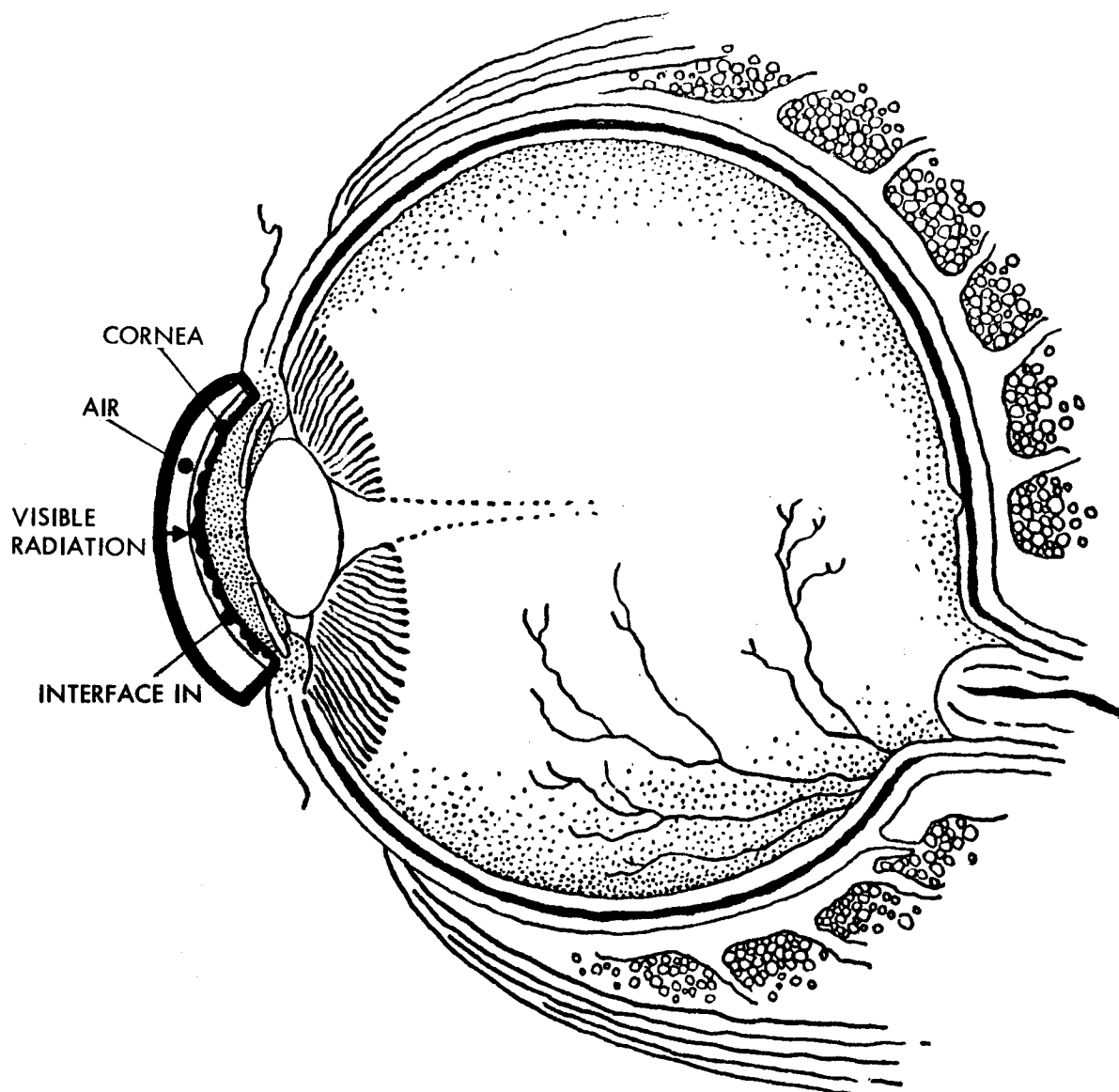
FROM: ATLAS OF HUMAN ANATOMY,  
FIFTH EDITION, BARNES AND  
NOBLE, 1959, p 138

COMPONENTS OF THE EYE IN VISIBLE RADIATION PATH  
TRANSVERSE SECTION OF EYE  
ENVIRONMENT INFLUENCING FACTOR

DRAWING NO: 4-05-01-1

TSC 2218A

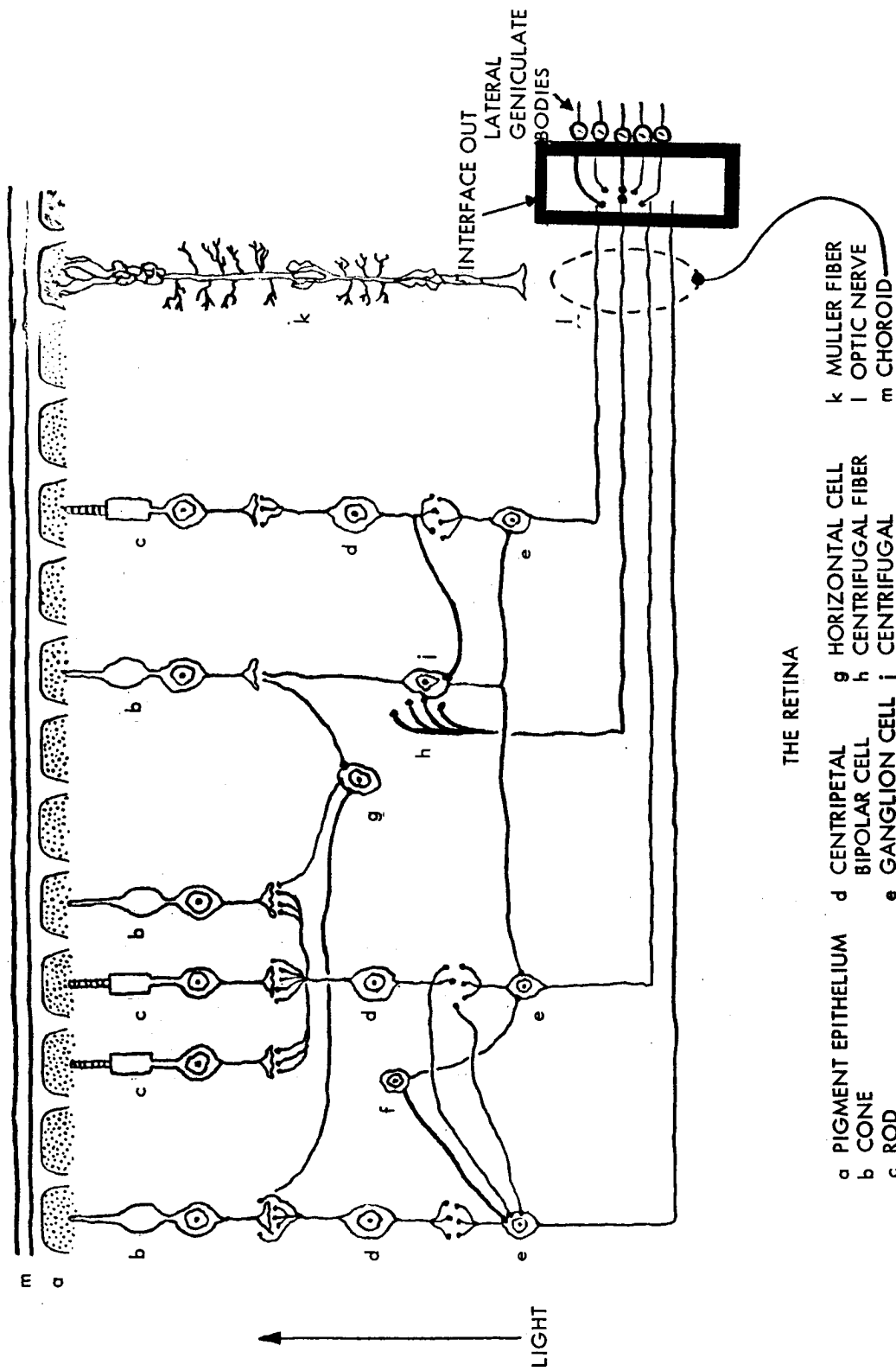
DRAWING NO: 4-05-01-2



CONFIGURATION - INTERFACE IN  
TRANSVERSE SECTION OF EYE  
ENVIRONMENT INFLUENCING FACTOR

DRAWING NO: 4-05-01-2

TSC 2218B



CONFIGURATION - INTERFACE OUT  
ENVIRONMENT INFLUENCING FACTOR

DRAWING NO: 4-05-01-3

TSC 2219A

# MATERIAL INFORMATION

ELEMENT: Man, Input, Sensory, Visual

FILE NO:

4-05-01

MATERIALS  
(next level)

MATERIALS

TYPE:

cornea

aqueous humor

iris

lens

vitreous body

choroid

rods

cones

pigment epithelium

REMARKS:

RELATIVE  
COST

PRODUCIBILITY

AVAILABILITY

EXISTENCE

### Guide to System Design Sheet

The first intersection that was encountered on the subsystem level matrix chart (shown on following page) under the function influencing factor was identified as 4-78-01. This intersection provided for a general functional breakdown of the entire eye into the segments of input, distribution and control, and output. A System Design sheet was used to present the "Major Components of the Eye".

There are two interfaces on the System Design sheet that require an explanation. The first is between the input and the distribution and control portions of the eye. It was hypothesized that electrons are transmitted between the rod and cone surface and the rod and cone proper. Between the distribution and control and the output portions, experimental evidence has verified that there is transverse ion flow.

[illegible]

This sheet is only a portion of the entire  
Subsystem/Function Matrix sheet.

SYSTEM DESIGN							
FILE NO.:	ITEM	DWG NO.	ITEM	DWG NO.	ITEM	UNIT	AMT
4-78-01	SHAPE		SUPPORT STRUCTURE		DIMENSIONS		
	ARRANGEMENT		CONTAINER		VOLUME		
	CONNECTION OF PARTS				WEIGHT		

SYSTEM FUNCTIONAL BLOCK DIAGRAM

```

graph LR
    subgraph INPUT
        direction TB
        I1[cornea]
        I2[aqueous humor]
        I3[iris proper]
        I4[sphincter muscle]
        I5[dilator muscle]
        I6[lens proper]
        I7[ciliary muscle]
        I8[vitreous body]
        I9[choroid]
        I10[pigment epithelium]
        I11[rod surface]
        I12[cone surface]
    end

    subgraph DISTRIBUTION_AND_CONTROL [DISTRIBUTION AND CONTROL]
        direction TB
        D1[rod proper]
        D2[cone proper]
        D3[centripetal cell]
        D4[horizontal cell]
        D5[amacrine cell]
        D6[centrifugal cell]
        D7[centrifugal fiber]
        D8[muller fiber]
        D9[ganglion cell]
    end

    subgraph OUTPUT
        direction TB
        O1[optic nerve]
        O2[sclera]
        O3[superior rectus]
        O4[inferior rectus]
        O5[lateral rectus]
        O6[medial rectus]
        O7[superior oblique]
        O8[inferior oblique]
        O9[conjunctiva]
        O10[levator muscle]
    end

    INPUT -- "Electrons" --> DISTRIBUTION_AND_CONTROL
    DISTRIBUTION_AND_CONTROL -- "ION Flow" --> OUTPUT
  
```

**INPUT**

- cornea
- aqueous humor
- iris proper
- sphincter muscle
- dilator muscle
- lens proper
- ciliary muscle
- vitreous body
- choroid
- pigment epithelium
- rod surface
- cone surface

**DISTRIBUTION AND CONTROL**

- rod proper
- cone proper
- centripetal cell
- horizontal cell
- amacrine cell
- centrifugal cell
- centrifugal fiber
- muller fiber
- ganglion cell

**OUTPUT**

- optic nerve
- sclera
- superior rectus
- inferior rectus
- lateral rectus
- medial rectus
- superior oblique
- inferior oblique
- conjunctiva
- levator muscle

MAJOR COMPONENTS OF EYE

File No. 4-78-01

- 35 -

On the sample subsystem level matrix chart, page 34, the "78" is circled and the intersection 4-79-01 is blacked in. The outlined numeral indicates that intersection 78 has been previously considered, and the darkened square shows the intersection that is presently being investigated. Thus attention is drawn to the functional aspect of input, data, detect.

In the first column of the function information sheet, the aspect was recorded as detect. This aspect is a description of how the eye initially becomes aware that a visible image is directing radiation toward the visual sensor. The object asked for in the second column is the visible image which sends visible radiation to the eye. Visible radiation is the parameter of the object. Following parameter, the next column lists the properties of the visible radiation. These properties are frequency and intensity. The characteristic of frequency is given as periodicity.

Next, the "Convert To" column provides space to state the modified energy form of the object after detection has taken place. To fill in this column, an understanding must be obtained of what occurs in the eye when detection of visible radiation takes place. A search of the literature yielded no explanation of the detection function, and thus a hypothesis was made.

The hypothesis was developed by attempting to explain the interaction between visible radiation and materials of the eye that are affected by light. This hypothesis was formulated by explaining interactions between electromagnetic waves and atoms. A discussion of this type

involves basic physics relationships, and thus the details of the hypothesis will be presented at a lower level of the Methodology. It is not necessary to become involved in these details at the subsystem level. All that need be said here is that the hypothesis is based on the phenomenon of resonance, and leads to the statement that radiation detection takes place by means of resonance.

When the resonance hypothesis is extended to the eye, structures can be found in the surface of the receptors that have a latent ability to resonate. This latent ability is utilized, and resonance is excited by the visible radiation that is striking the surface of the receptors.

Now the "Convert To" column could be filled out. The visible image transmits energy to the eye that is absorbed by resonance in some structure within the eye. Under "Method" the statement is made that there is an interaction of the electromagnetic field with the resonant structure and the method sub-detail no. 1 is concerned with the fact that forces are exerted on the resonant structure.

At the subsystem level, the mechanism could not be described, but the operation was stated. To explain the operation, it was noted that detection begins when visible radiation strikes the cornea and continues as transmission takes place through the eye. Finally the visible radiation penetrates the surface of the receptors (rods and cones); here absorption occurs - resonance takes place - and an energy conversion is brought about. The function of detection is completed by this initial energy conversion.

File No: 4-79-01

The Configuration Information sheet was next filled out. Only the Configurational aspect concerned with parts was considered because this is the one aspect that is involved in detection. Drawings were made to illustrate the process of detection as well as to show the anatomical parts of the eye concerned with this aspect.

A function schematic was drawn, Drawing 4-79-01-1. At the top of this drawing, the three steps in detection are shown, while the remainder of the illustration depicts those parts of the eye that carry out the process. Acceptance of visible radiation is shown to take place at the cornea and the transmission of the radiation is through the aqueous humor, lens and vitreous body. Finally resonance is excited in the receptor (rod and cone) surface. The cross sectional view of the receptors indicates that the surface, not the receptor proper, contains the resonant structure.

On Drawing 4-79-01-2, the Interface In is shown. This is the interface where the aspect of detection begins. The drawing indicates that the portion of the cornea that is exposed to the air is the Interface In.

The next drawing shows the Interface Out. This is Drawing 4-79-01-3. On this sheet a cross sectional view of a receptor is shown. The illustration indicates that the detection function is completed at the border of the receptor surface and receptor proper.

Listed on the Material Information sheet are those components of the eye that are involved in the detection of visible radiation.

SUBSYSTEM  FUNCTION			MAN																MACHINE												
			INPUT								DIST. AND CONTROL				OUTPUT				INPUT				DIST. AND CONTROL				OUTPUT				
			SENSORY					RESPIRATORY	UPPER G.I. TRACT	RADIATION	CARDIOVASCULAR	ENDOCRINE	NERVOUS	SMALL INTESTINE	MUSCULO SKELETAL	SKIN	EXCRETORY	REPRODUCTIVE	SENSORS				POWER	CIRCUITS CONTROL	CIRCUITS INFORMATION HANDLING	HEAD AND WASTE DISSIPATION	ACTUATORS	DISPLAYS	RADIATION		
			VISUAL	AUDITORY	GUSTATORY	OLFACTORY	TACTILE												RADIATION	MAGNETIC	ELECTRO-STATIC	FORCE								CHEMICAL	
			01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29
INPUT	DATA	DETECT	79																												
		QUANTIZE	80																												
		QUALIFY	81																												
		TRANSDUCE	82																												
		DISCARD NOISE	83																												
		TRANSMIT INFO. SIGNAL	84																												
	POWER	ACQUIRE	85																												
		QUANTIZE	86																												
		QUALIFY	87																												
		CONVERT	88																												
		DISCARD WASTE	89																												
DISTRIBUTION AND CONTROL	DATA	ACCEPT INFO. SIGNAL	90																												
		ACCEPT INT. CONTROL SIGNAL	91																												
		CONVERT INFO. SIGNAL	92																												
		CORR. CONV. SIG. TO STORE	93																												
		CONV. STORED SIG. TO DEC.	94																												
	POWER	TRANSMIT DEC. SIGNAL	95																												
		ACQUIRE EXT. POWER	96																												
		ACCEPT INT. POWER	97																												
		CONVERT POWER TO STORE	98																												
		CORRELATE STORED POWER	99																												
OUTPUT	POWER	CONV. STORED POWER TO INPUT	100																												
		DISCARD WASTE	101																												
		ACCEPT DEC. SIGNAL	102																												
		CONVERT TO ACTION	103																												
		CORR. WITH STORE	104																												
		TRANSMIT ACTION SIG.	105																												
		RETRIEVE STORED POWER	106																												
DATA	CONV. TO ACTION	107																													
	CORR. WITH STORE	108																													
	TRANSMIT ACTION	109																													
	SUBSYSTEM																														
CONFIGURATION			110																												
		PARTS	111																												
		SUPPORT STRUCTURE	112																												
		CONTAINER	113																												
		INTERNAL DYNAMICS	114																												
		EXTERNAL DYNAMICS	115																												
SUBSYSTEM																															
MATERIALS			116																												
		ACCELERATABLE MASSES	117																												
		CONSTRAINED MASSES	118																												
		CHEMICAL CELLS	119																												
		RADATION SOURCES	120																												
		PERMANENT MAGNETS	121																												
		ELECTRETS	122																												
		CONDUCTING LOOPS	123																												
		CONDUCTING SURFACES	124																												
		NON-CONDUCTORS	125																												
		SUBSYSTEM																													
TASKS			126																												
			127																												
			128																												
			129																												
			130																												
			131																												
			132																												
			133																												
			134																												
			135																												
			136																												

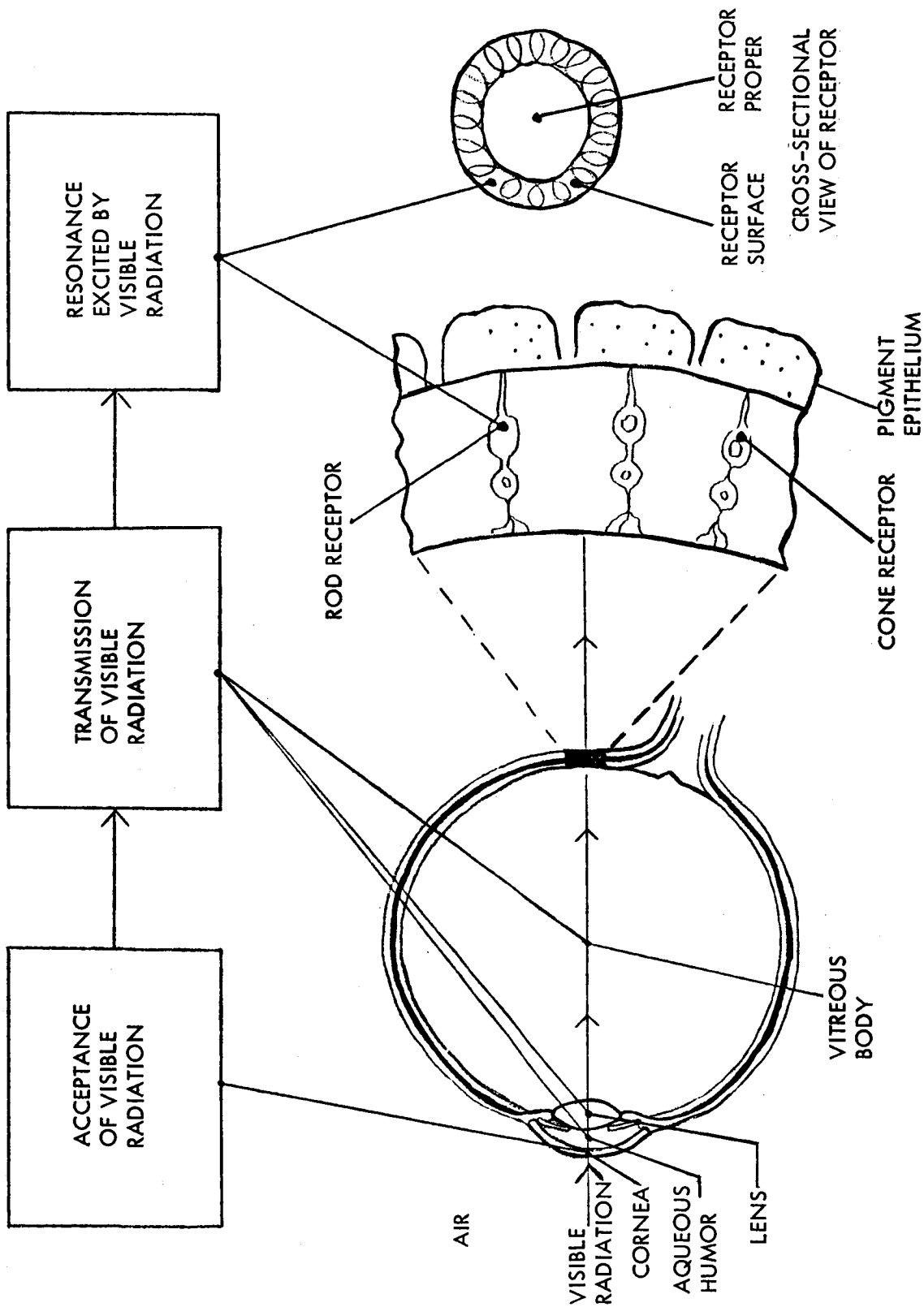
# FUNCTION INFORMATION

ELEMENT: MAN, INPUT, SENSORY, VISUAL												
FILE NO: 4-79-01												
DEFINITION FUNCTION	OBJECT	PARA- METER	PROPERTY	CHARACT- ERISTIC	CONVERT TO	METHOD	METHOD SUB-DETAIL NO.1	METHOD SUB-DETAIL NO.2	MECH- ANISM	OPERATION SUB-DETAIL NO.1	OPERATION SUB-DETAIL NO.2	CHANGE WHEN TOLERABLE LIMITS ARE EXCEEDED
ASPECT: Detect	visible image	visible radia- tion	freq- uency and inten- sity	period- icity and ampli- tude	reson- ance in a struc- ture	inter- action of electro- mag- netic field with reson- ant struc- ture	force on a struc- ture			trans- mission absorp- tion of visible radia- tion		

TSC1642

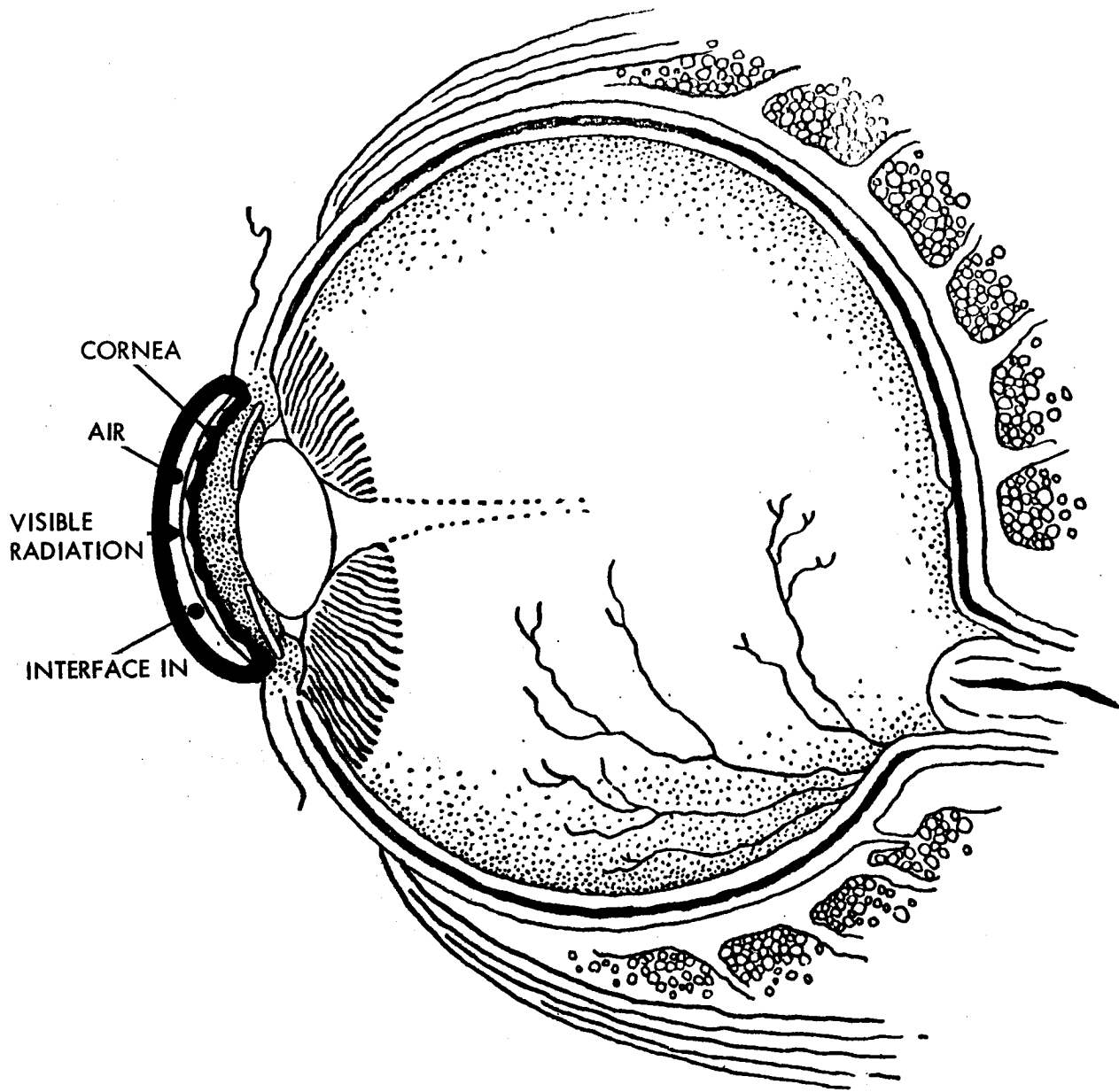
[illegible]

DRAWING NO.: 4-79-01-1



DETECTION FUNCTIONAL SCHEMATIC  
TRANSVERSE SECTION OF EYE  
CONFIGURATION - CONNECTION OF PARTS  
DRAWING NO.: 4-79-01-1

TSC 2531

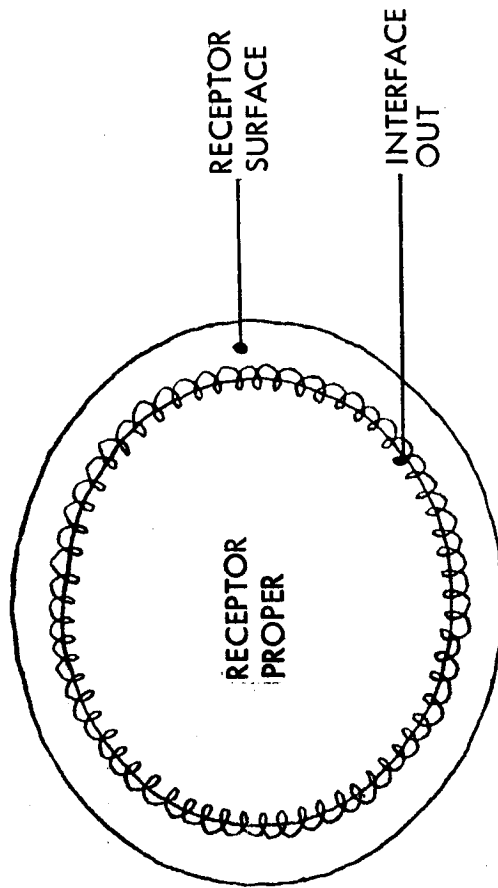


CONFIGURATION - INTERFACE IN  
TRANSVERSE SECTION OF EYE  
DETECTION FUNCTION ASPECT

DRAWING NO: 4-79-01-2

TSC 2218C

DRAWING NO.: 4-79-01-3



CONFIGURATION - INTERFACE OUT  
CROSS SECTION OF RECEPTOR  
DETECTION FUNCTIONAL ASPECT  
DRAWING NO.: 4-79-01-3

TSC 2529

[illegible]

TSC 1643

The function aspect of quantize includes an explanation of how the eye determines the amount of visible radiation present. In describing how the Function Information sheet was filled out, the column labeled Object will be discussed first. The Object is found by considering the function of detection which precedes quantization. As soon as the eye has detected the visible radiation, the quantization conversion may begin.

It will be necessary to continue with the resonance hypothesis to explain the quantization conversion that begins in the resonant structures of the surface of the receptors which is where the detection conversion terminates. In the column labeled Object, the energy of the resonant structure is listed.

There are a number of columns on the function sheet that are blank. These spaces could not be filled in on the subsystem level because the details involved are on the chemical and atomic levels.

When the energies absorbed by the resonating structures become large enough, electrons are dislodged from their bonds and flow from the receptor surface into the receptor proper. Thus the "Convert To" column indicates that the energy has been changed to the kinetic motion of electrons. The quantization is completed by this conversion because the energy of the electrons is in proportion to the activity of the visible radiation that is absorbed by the resonant structure.

There are a number of drawings called out on the Configuration Information sheet. The first is a functional schematic of quantization, Drawing 4-80-01-1. This illustration is similar in form to the functional schematic of detection that was previously discussed. The quantization conversion takes place in the receptor surface and produces electrons that are transmitted to the receptor proper.

On the following illustration, Drawing 4-80-01-2, the energy dissipation in the eye is shown. Prior to the energy conversion described, visible radiation is dissipated in the components of the eye. The drawing indicates the penetration of 100 quanta at the cornea, and the resulting energy in the parts of the eye.

Drawing 4-80-01-3 indicates that quantization of visible radiation begins at the cornea, while Drawing 4-80-01-4 shows that the quantization conversion ends at the interface between the receptor surface and receptor proper.

The Material Information sheet lists the components of the eye involved in the function of quantization.

[illegible]

# FUNCTION INFORMATION

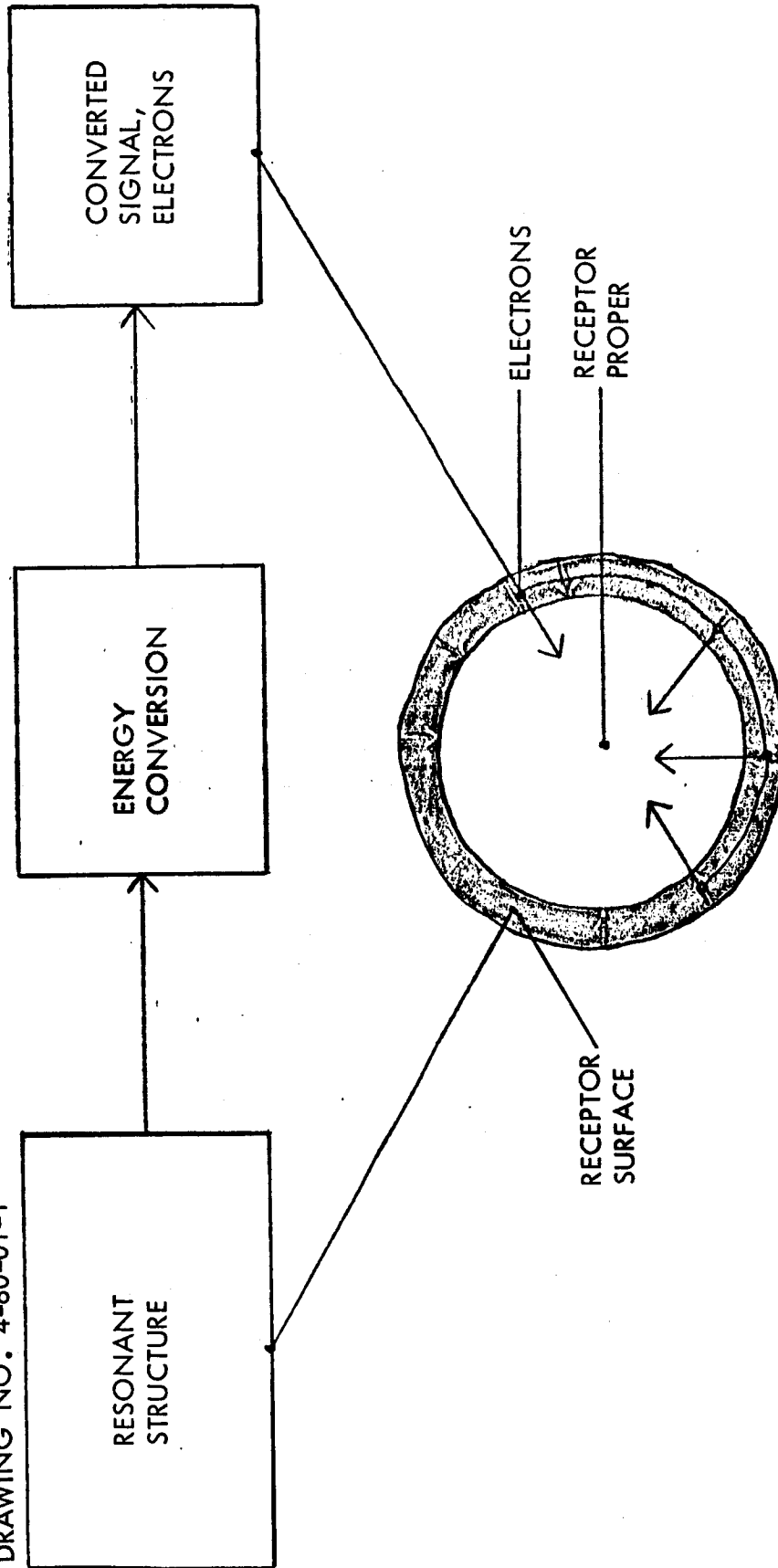
ELEMENT: Man, Input, Sensory, Visual												
FILE NO: 4-80-01												
DEFINITION FUNCTION	OBJECT	PARA- METER	PROPERTY	CHARACT- ERISTIC	CONVERT TO	METHOD	METHOD SUB-DETAIL NO.1	METHOD SUB-DETAIL NO.2	MECH- ANISM	OPERATION SUB-DETAIL NO.1	OPERATION SUB-DETAIL NO.2	CHANGE WHEN TOLERABLE LIMITS ARE EXCEEDED
ASPECT:  Quantize	Energy of reson- ant struc- ture				kinetic motion of elec- trons					conver- sion of energy		

TSCI642

## CONFIGURATION INFORMATION

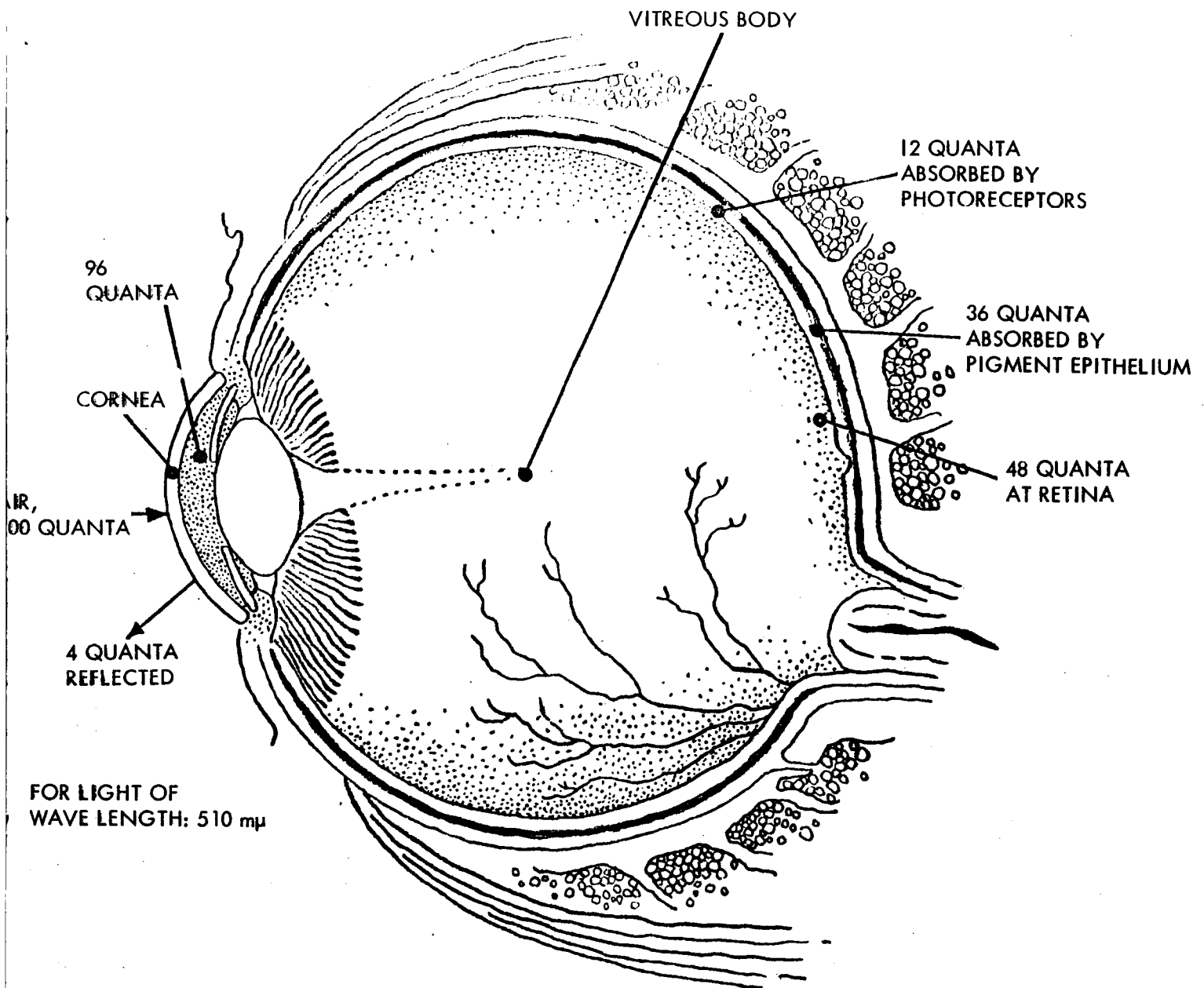
[illegible]

DRAWING NO. 4-80-01-1



QUANTIZATION FUNCTIONAL SCHEMATIC  
CROSS-SECTION OF RECEPTOR  
CONFIGURATION-CONNECTION OF PARTS

DRAWING NO. 4-80-01-1 TSC 2556

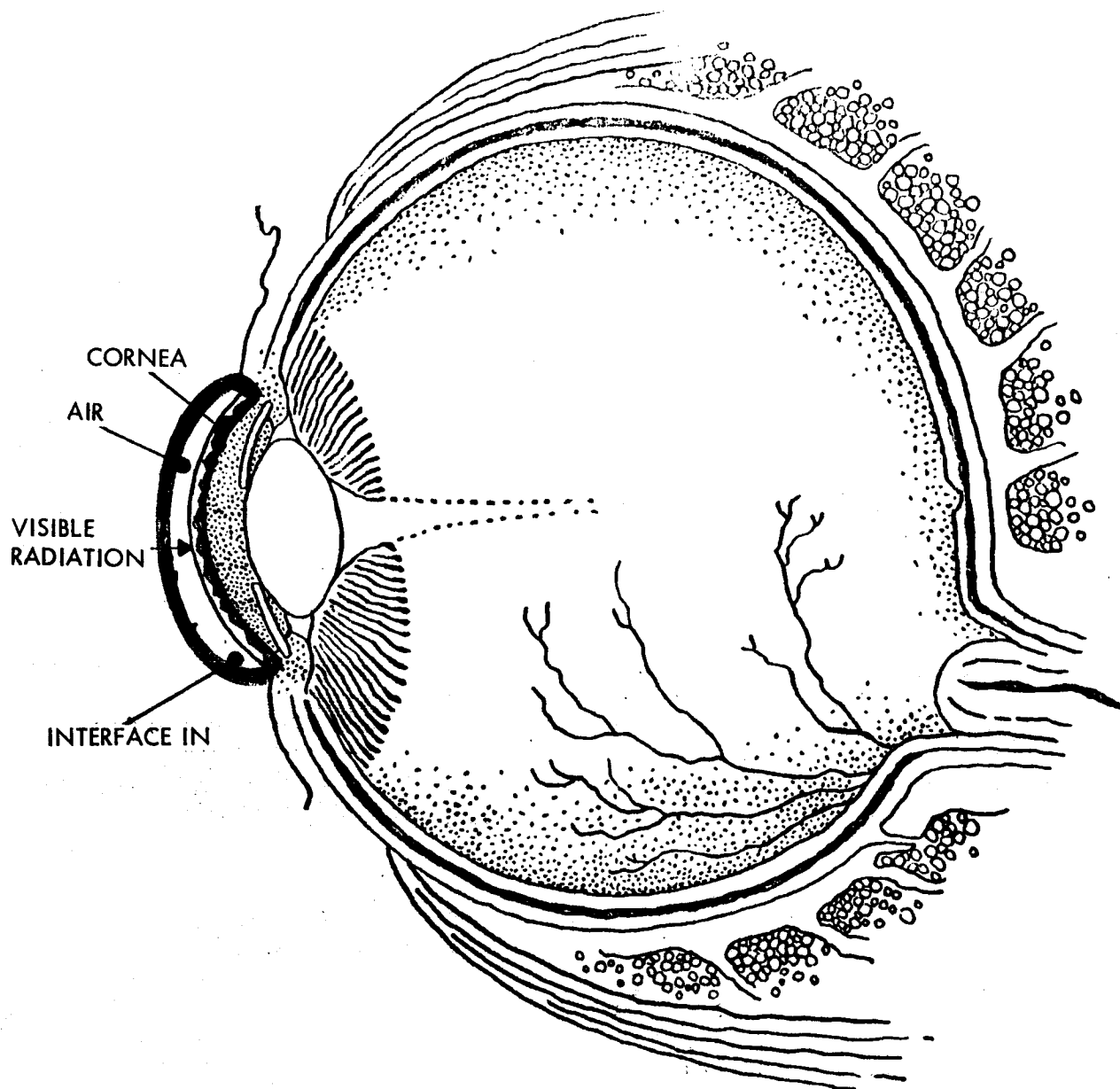


(DATA SOURCE: HARTRIDGE, H., RECENT ADVANCES IN  
THE PHYSIOLOGY OF VISION, 1950, p. 24)

ENERGY DISSIPATION IN EYE  
QUANTIZATION FUNCTIONAL ASPECT  
CONFIGURATION-CONNECTION OF PARTS

DRAWING NO: 4-80-01-2

TSC 2218D

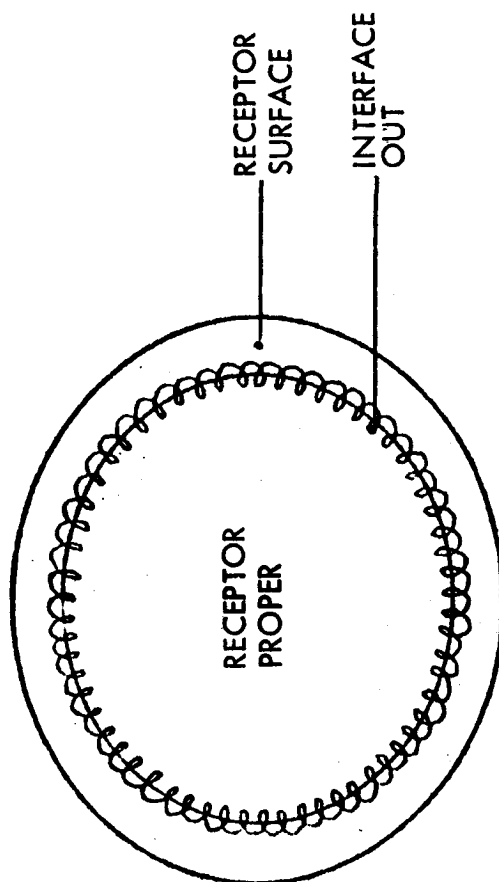


CONFIGURATION - INTERFACE IN  
TRANSVERSE SECTION OF EYE  
QUANTIZATION FUNCTIONAL ASPECT

DRAWING NO: 4-80-01-3

TSC 2218E

DRAWING NO.: 4-80-01-4



CONFIGURATION - INTERFACE OUT  
CROSS SECTION OF RECEPTOR  
QUANTIZATION FUNCTION  
DRAWING NO: 4-80-01-4

TSC 2528

[illegible]

File No: 4-81-01

An explanation concerned with the determination of what is present in the radiation striking the eye is the subject of the qualification aspect. The qualification conversion begins simultaneously with the detection conversion and precedes the quantization conversion.

In order to fill in the Function Information sheet, the two basic properties of visible radiation - frequency and intensity - should be examined. Frequency filtering cannot be investigated since the environment external to the eye was chosen to be visible radiation and the light sensitive components (rods and cones) of the visual sensor responded to this entire range of excitation. However, it should be realized that penetrating the cornea is a range of frequencies ( $1 \times 10^{14}$  to  $10 \times 10^{14}$  cps, Adler, F. A., Physiology of the Eye, p. 498) that are filtered down to the visible range ( $4.15 \times 10^{14}$  to  $7.56 \times 10^{14}$ , Fulton, J. F., A Textbook of Physiology, p. 446). Relatively transparent portions of the eye which include the cornea, aqueous humor, lens, vitreous body and retina take part in the filtering. These same components also attenuate light intensities as a function of frequency.

Now the column labeled Object on the Function Information sheet may be filled in. "Light frequencies contained in the visible image" is the Object that is converted to light that has experienced intensity attenuation as a function of frequency. The operation is filtering, and sub-detail no. 1 is reflection and absorption of light that takes place as radiation penetrates the components of the eye.

File No: 4-81-01

The first drawing listed on the Configuration Information sheet is the Qualification Functional Schematic, Drawing No. 4-81-01-1. As diagramed on this sheet, the light from the visual image is filtered and sent to the resonant structures that are in the rods and cones.

Following this sheet is Drawing No. 4-81-01-2 that indicates the refractive indices of the components of the eye. This drawing shows that visible radiation undergoes modification continuously as it passes through the sensor. As radiation is transmitted through the eye reflection and absorption take place.

The next drawing, number 4-81-01-3, indicates that the qualification function begins at the air-cornea interface. Drawing No. 4-81-01-4 shows that the qualification function terminates at the surface of the receptor.

A listing of the components of the eye involved in qualification is presented on the Material Information sheet.

This file will not discuss how the eye determines the frequency of the light striking the rods and cones. Such a determination involves the perception of color which is a topic that will be examined in the final report.

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# FUNCTION INFORMATION

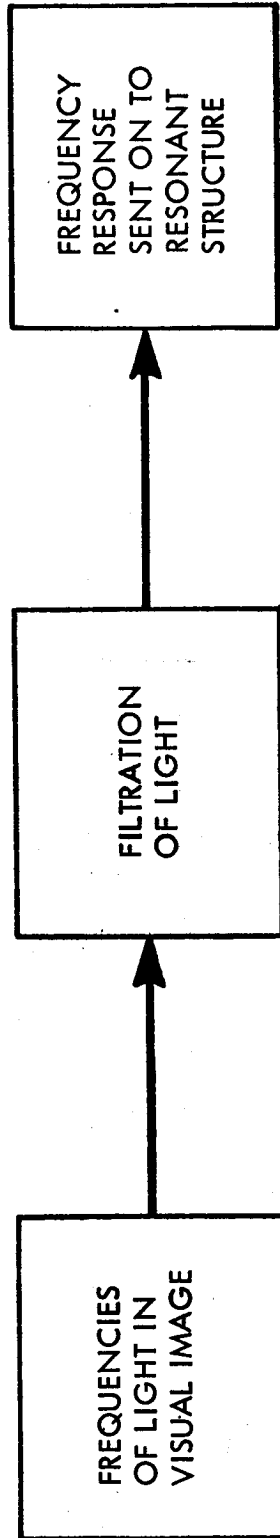
ELEMENT: Man, Input, Sensory, Visual												
FILE NO: 4-81-01												
DEFINITION FUNCTION	OBJECT	PARA-METER	PROPERTY	CHARACTERISTIC	CONVERT TO	METHOD	METHOD SUB-DETAIL NO.1	METHOD SUB-DETAIL NO.2	MECHANISM	OPERATION SUB-DETAIL NO.1	OPERATION SUB-DETAIL NO.2	CHANGE WHEN TOLERABLE LIMITS ARE EXCEEDED
ASPECT:  qualify	light frequencies contained in visible image				light that has experienced intensity attenuation as a function of frequency					filter-reflecting as a function of frequency		

TSC1642

## CONFIGURATION INFORMATION

[illegible]

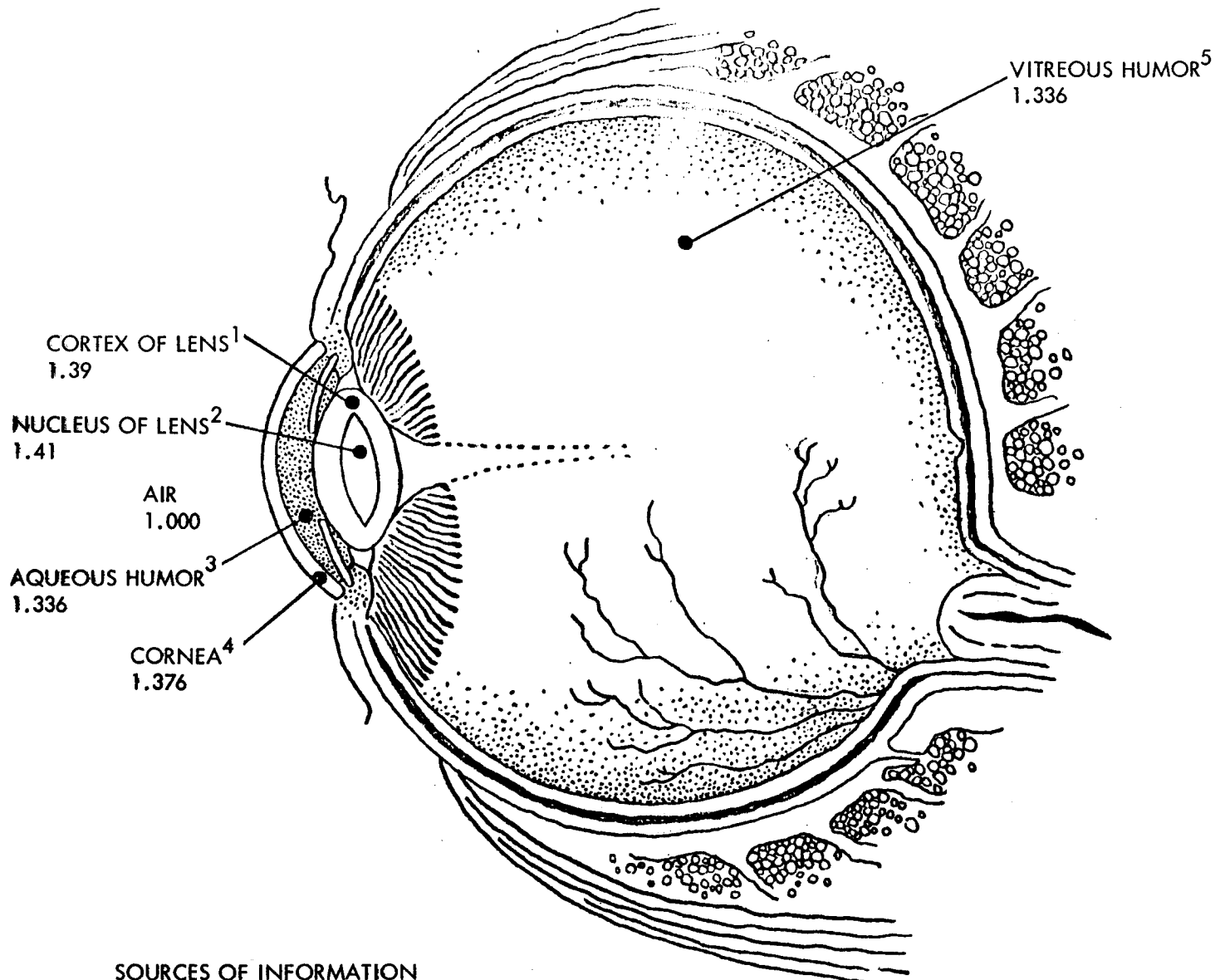
DRAWING NO. 4-81-01-1



QUALIFICATION FUNCTIONAL SCHEMATIC  
CONFIGURATION-CONNECTION OF PARTS

TSC 2555

DRAWING NO. 4-81-01-1

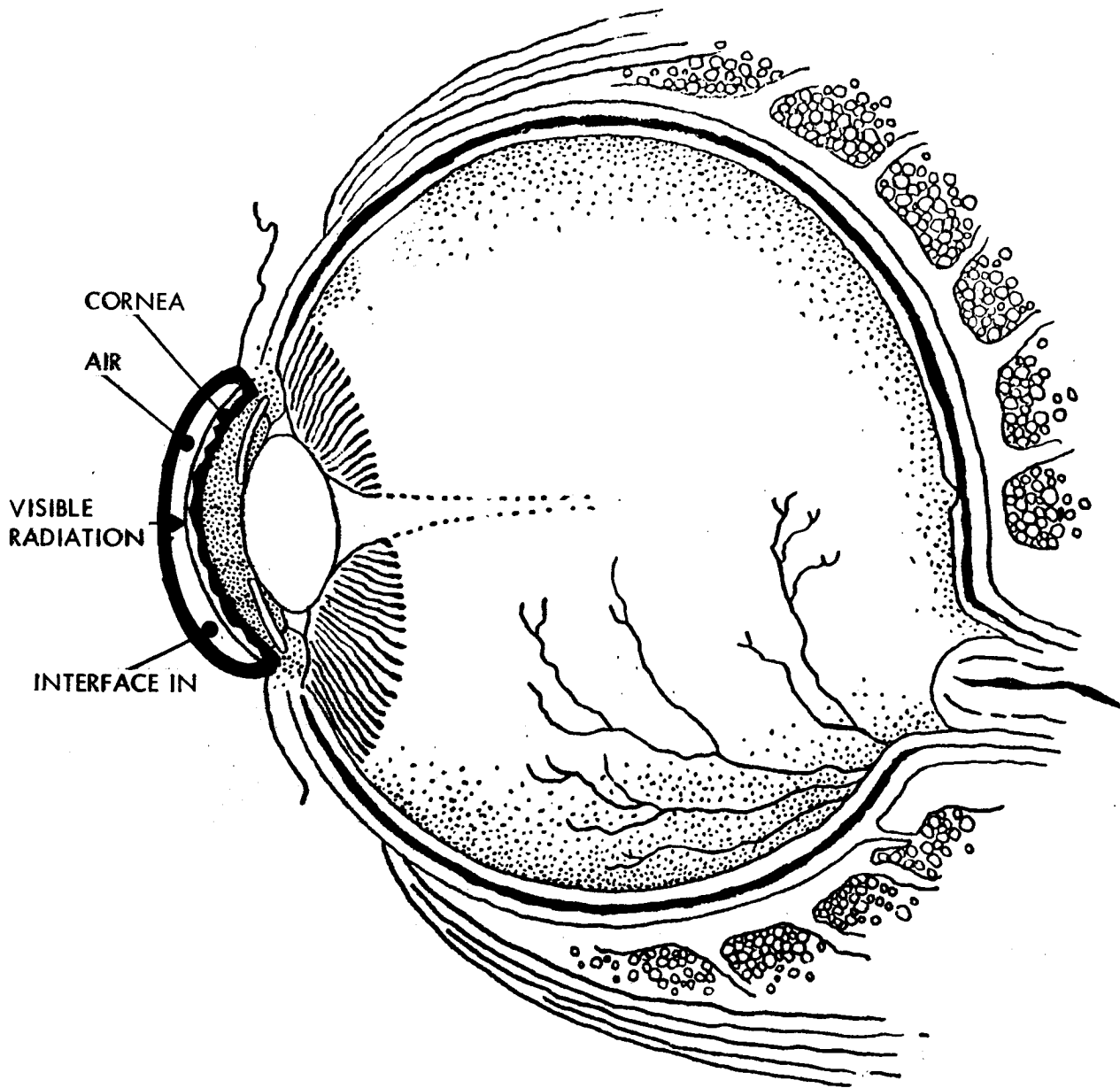


SOURCES OF INFORMATION

- 1) SPOONER, J.D., OCULAR ANATOMY, p. 38
- 2) SPOONER, J.D., p. 38
- 3) FULTON, J.F., A TEXTBOOK OF PHYSIOLOGY, p. 427
- 4) ADLER, F.H., PHYSIOLOGY OF THE EYE, p. 43
- 5) FULTON, J.F., p. 427

REFRACTIVE INDICES OF THE COMPONENTS OF THE EYE  
QUALIFICATION FUNCTIONAL ASPECT  
CONFIGURATION - CONNECTION OF PARTS  
DRAWING NO: 4-81-01-2

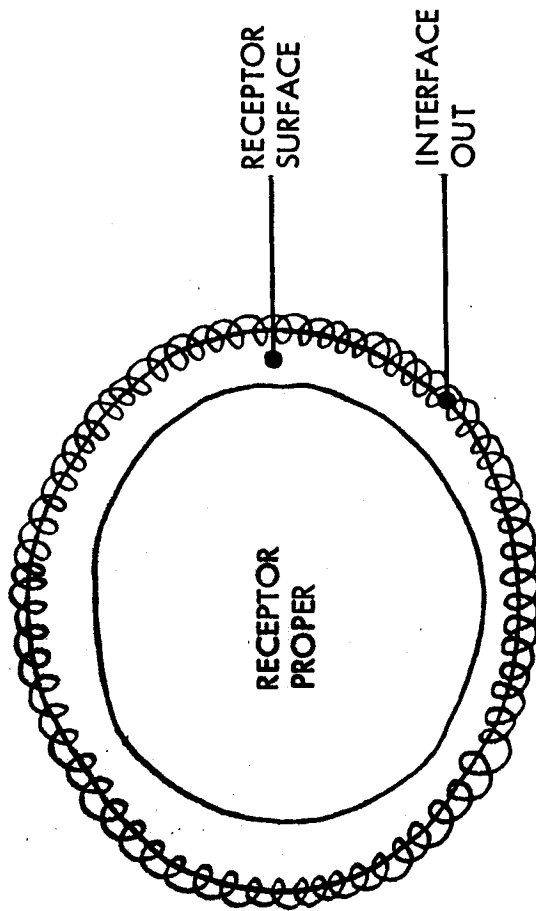
TSC 2218F



ENVIRONMENT-INTERFACE IN  
TRANSVERSE SECTION OF EYE  
QUALIFICATION FUNCTIONAL ASPECT

DRAWING NO: 4-81-01-3

DRAWING NO. 4-81-01-4



CONFIGURATION-INTERFACE OUT  
CROSS SECTION OF RECEPTOR  
QUALIFICATION FUNCTIONAL ASPECT

DRAWING ON.: 4-81-01-4

TSC 2527

[illegible]

- 65 -

The functional aspect called transduce deals with the initial energy conversion that takes place in the input portion of the eye. This conversion has been previously discussed while outlining the resonance hypothesis. As shown on the Function Information sheet, the Object is visible radiation which is converted to the kinetic motion of charges. The Operation is the absorption of light energy by the resonant structures in the surface of the receptors.

On the Configuration Information sheet, Drawing 4-82-01-1 is called out. This drawing shows a schematic representation of the conversion. Next the drawing, No. 4-82-01-2, of the Interface In is presented. The illustration indicates that the interface is bounded by the vitreous body and the receptor surface. From the central figure on the drawing, it is seen that the vitreous body is in contact with the layer of the eye that contains the rods and cones (the receptors). The layer is called the retina and contains a number of the components of the eye such as the receptors and the pigment epithelium. A drawing, No. 4-82-01-3, of the Interface Out is presented. From the drawing, it may be seen that the interface is bounded by the receptor surface and receptor proper.

A list of the components of the eye that are involved in the transduce function is presented on the Material Information sheet.

[illegible]

# FUNCTION INFORMATION

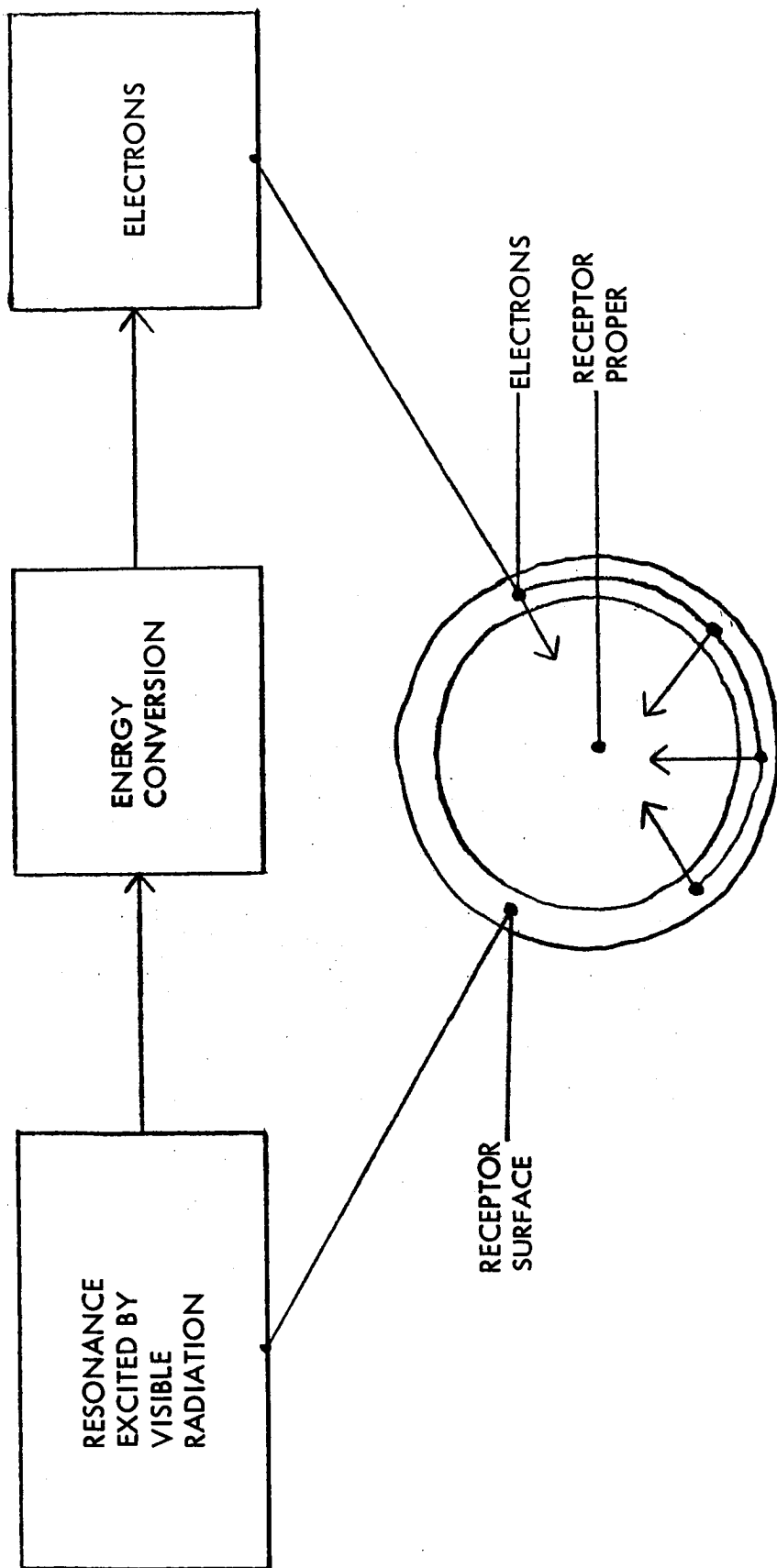
FILE NO: 4-82-01		ELEMENT: Man, Input, Sensory, Visual										CHANGE WHEN TOLERABLE LIMITS ARE EXCEEDED
DEFINITION FUNCTION	OBJECT	PARA- METER	PROPERTY	CHARACT- ERISTIC	CONVERT TO	METHOD	METHOD SUB-DETAIL NO.1	METHOD SUB-DETAIL NO.2	MECH- ANISM	OPERATION SUB-DETAIL NO.1	OPERATION SUB-DETAIL NO.2	
ASPECT: Transduce	visible image	visible radia- tion	freq- uency and inten- sity	period- icity and ampli- tude	kinetic motion of elec- trons	conver- sion of light energy				absorp- tion of light energy		

TSC1642

## CONFIGURATION INFORMATION

[illegible]

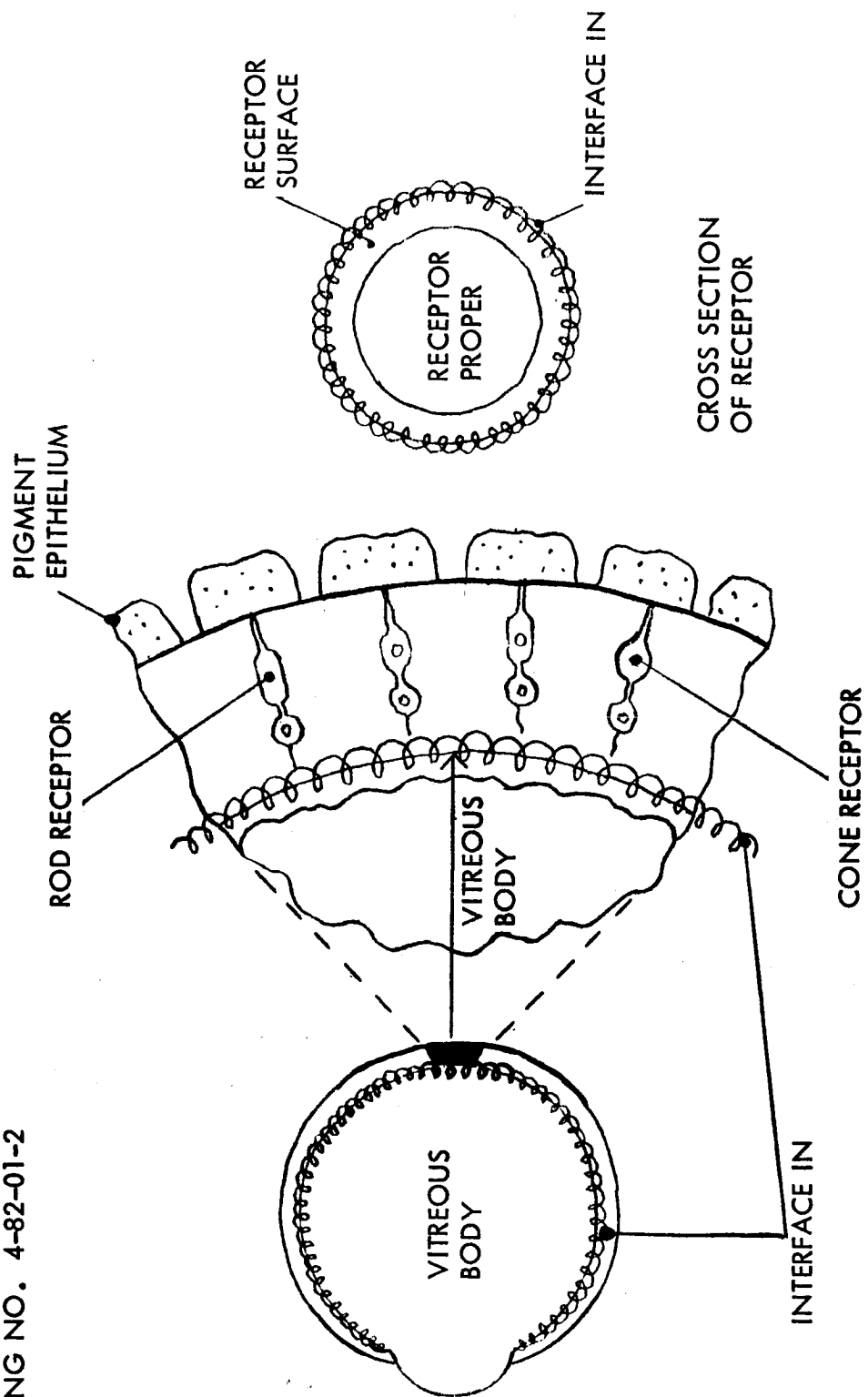
DRAWING NO. 4-82-01-1



TRANSDUCE FUNCTIONAL SCHEMATIC  
CROSS SECTION OF RECEPTOR  
CONFIGURATION - CONNECTION OF PARTS  
DRAWING NO: 4-82-01-1

TSC 2535

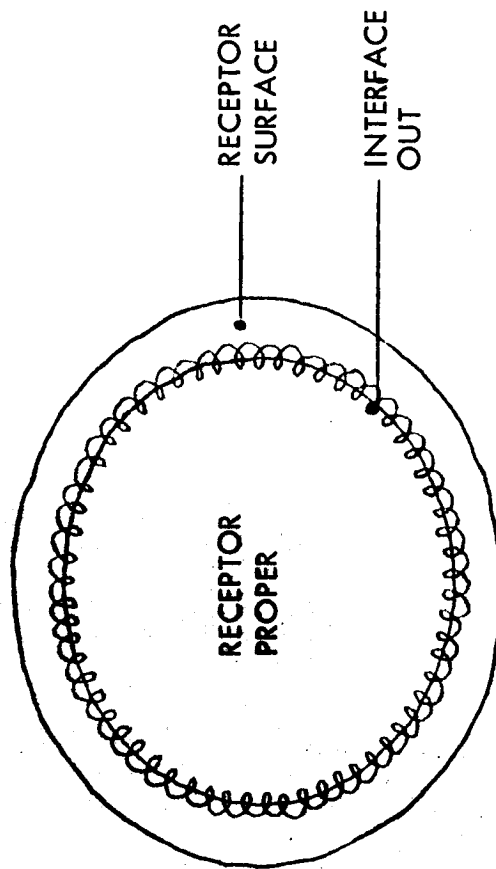
DRAWING NO. 4-82-01-2



TRANSVERSE SECTION OF EYE  
CONFIGURATION - INTERFACE IN  
TRANSDUCE FUNCTIONAL ASPECT  
DRAWING NO: 4-82-01-2

TSC 2533

DRAWING NO.: 4-82-01-3



CONFIGURATION - INTERFACE OUT  
CROSS-SECTION OF RECEPTOR  
TRANSDUCE FUNCTIONAL ASPECT  
DRAWING NO.: 4-82-01-3

TSC 2526

## MATERIAL INFORMATION

[illegible]

The Function Information sheet concerned with the aspect of discard noise discusses the threshold level to produce one free electron at the interface between the input and the distribution and control portions of the eye. The purpose of this threshold level is to discard noise signals that are below a specific amplitude. All of the entries on the Function Information sheet have been previously discussed.

Under the column labeled Connection of Parts on the Configuration Information sheet, drawing 4-83-01-1 is called out. The figure is a schematic of the discard noise function. It is shown that if the threshold level of intensity at a specific frequency impinges upon the receptor surface, one electron will be freed and will be transmitted into the receptor proper.

The Interface In, Drawing 4-83-01-2, shows that the vitreous body and receptor proper form the initial boundary of the discard noise function. Electrons that have been produced in the input portion of the eye leave through the Interface Out, Drawing 4-83-01-3, that is bounded by the receptor surface and receptor proper.

On the Material Information sheet, the rods, cones and pigment epithelium are listed as the components that take part in discarding noise.

SUBSYSTEM  FUNCTION			MAN																MACHINE												
			INPUT								DIST. AND CONTROL				OUTPUT				INPUT				DIST. AND CONTROL				OUTPUT				
			SENSORY					RESPIRATORY	UPPER G.I. TRACT	RADIATION	CARDIOVASCULAR	ENDOCRINE	NERVOUS	SMALL INTESTINE	MUSCULO SKELETAL	SKIN	EXCRETORY	REPRODUCTIVE	SENSORS				POWER	POWER CIRCUITS	CONTROL CIRCUITS	INFORMATION HANDLING	HEAD AND WAIST DISSIPATION	ACTUATORS	DISPLAYS	RADIATION	
			VISUAL	AUDITORY	GUSTATORY	OLFACTORY	TACTILE												RADIATION	MAGNETIC	ELECTRO-STATIC	FORCE									CHEMICAL
			01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29
INPUT	DATA	DETECT	79																												
		QUANTIZE	80																												
POWER		QUALIFY	81																												
		TRANSDUCE	82																												
DISTRIBUTION AND CONTROL	DATA	DISCARD NOISE	83																												
		TRANSMIT INFO. SIGNAL	84																												
POWER		ACQUIRE	85																												
		QUANTIZE	86																												
		QUALIFY	87																												
		CONVERT	88																												
		DISCARD WASTE	89																												
		ACCEPT INFO. SIGNAL	90																												
		ACCEPT INT. CONTROL SIGNAL	91																												
		CONVERT INFO. SIGNAL	92																												
		CORR. CONV. SIG. TO STORE	93																												
		CONV. STORED SIG. TO DEC.	94																												
		TRANSMIT DEC. SIGNAL	95																												
		ACQUIRE EXT. POWER	96																												
		ACCEPT INT. POWER	97																												
		CONVERT POWER TO STORE	98																												
		CORRELATE STORED POWER	99																												
		CONV. STORED POWER TO INPUT	100																												
		DISCARD WASTE	101																												
		ACCEPT DEC. SIGNAL	102																												
		CONVERT TO ACTION	103																												
		CORR. WITH STORE	104																												
		TRANSMIT ACTION SIG.	105																												
		RETRIEVE STORED POWER	106																												
		CONV. TO ACTION	107																												
		CORR. WITH STORE	108																												
		TRANSMIT ACTION	109																												
		SUBSYSTEM																													
CONFIGURATION			110																												
		PARTS	111																												
		SUPPORT STRUCTURE	112																												
		CONTAINER	113																												
		INTERNAL DYNAMICS	114																												
		EXTERNAL DYNAMICS	115																												
SUBSYSTEM																															
MATERIALS			116																												
		ACCELERATABLE MASSES	117																												
		CONSTRAINED MASSES	118																												
		CHEMICAL CELLS	119																												
		RADATION SOURCES	120																												
		PERMANENT MAGNETS	121																												
		ELECTRETS	122																												
		CONDUCTING LOOPS	123																												
		CONDUCTING SURFACES	124																												
		NON-CONDUCTORS	125																												
		SUBSYSTEM																													
TASKS			126																												
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			136																												</

# FUNCTION INFORMATION

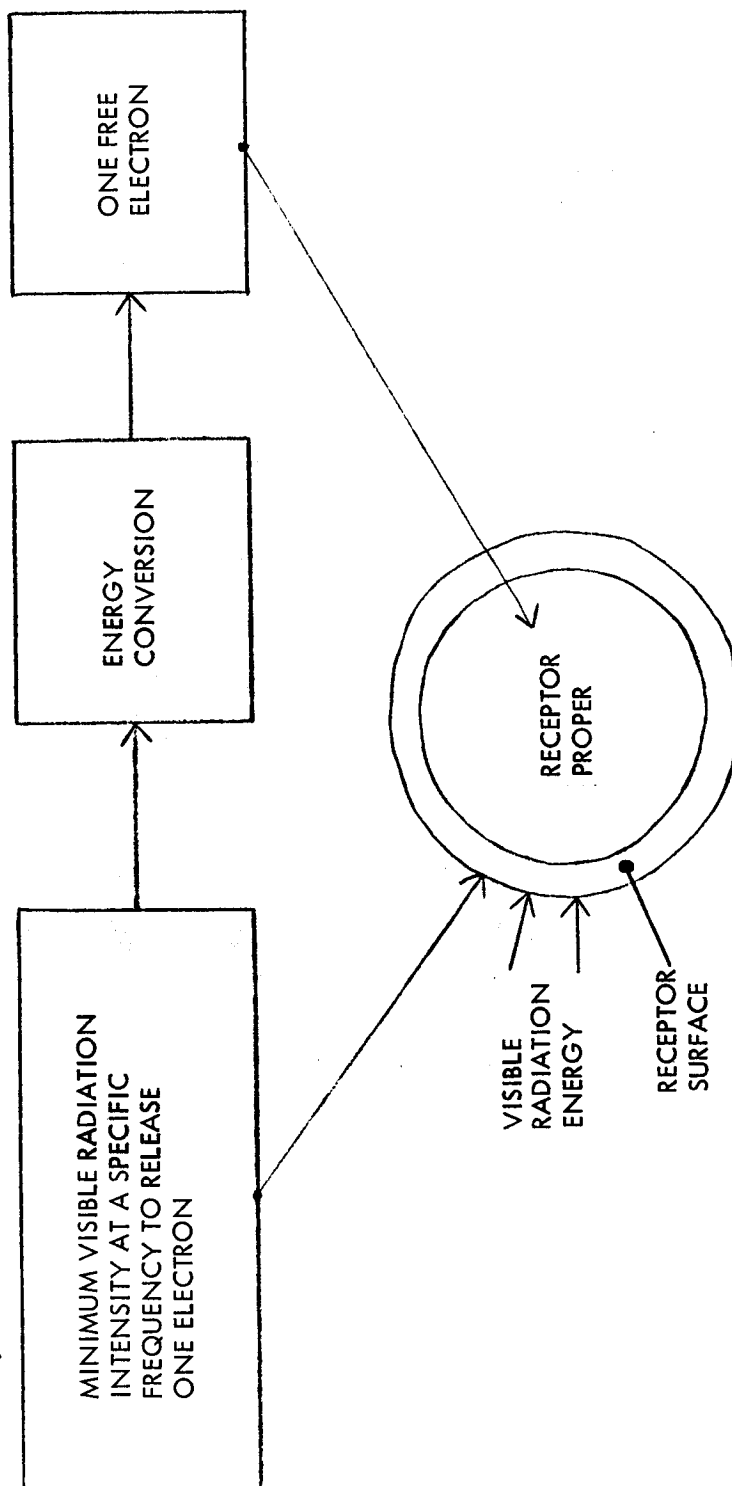
FILE NO: 4-83-01		ELEMENT: Man, Input, Sensory, Visual											
DEFINITION FUNCTION		OBJECT	PARAMETER	PROPERTY	CHARACTERISTIC	CONVERT TO	METHOD	METHOD SUB-DETAIL NO.1	METHOD SUB-DETAIL NO.2	MECHANISM	OPERATION SUB-DETAIL NO.1	OPERATION SUB-DETAIL NO.2	CHANGE WHEN TOLERABLE LIMITS ARE EXCEEDED
ASPECT:  Discard Noise		visible image	visible radiation	frequency and intensity	periodicity	kinetic motion of electrons	energy conversion in receptor						
							</						

TSC1642

## CONFIGURATION INFORMATION

[illegible]

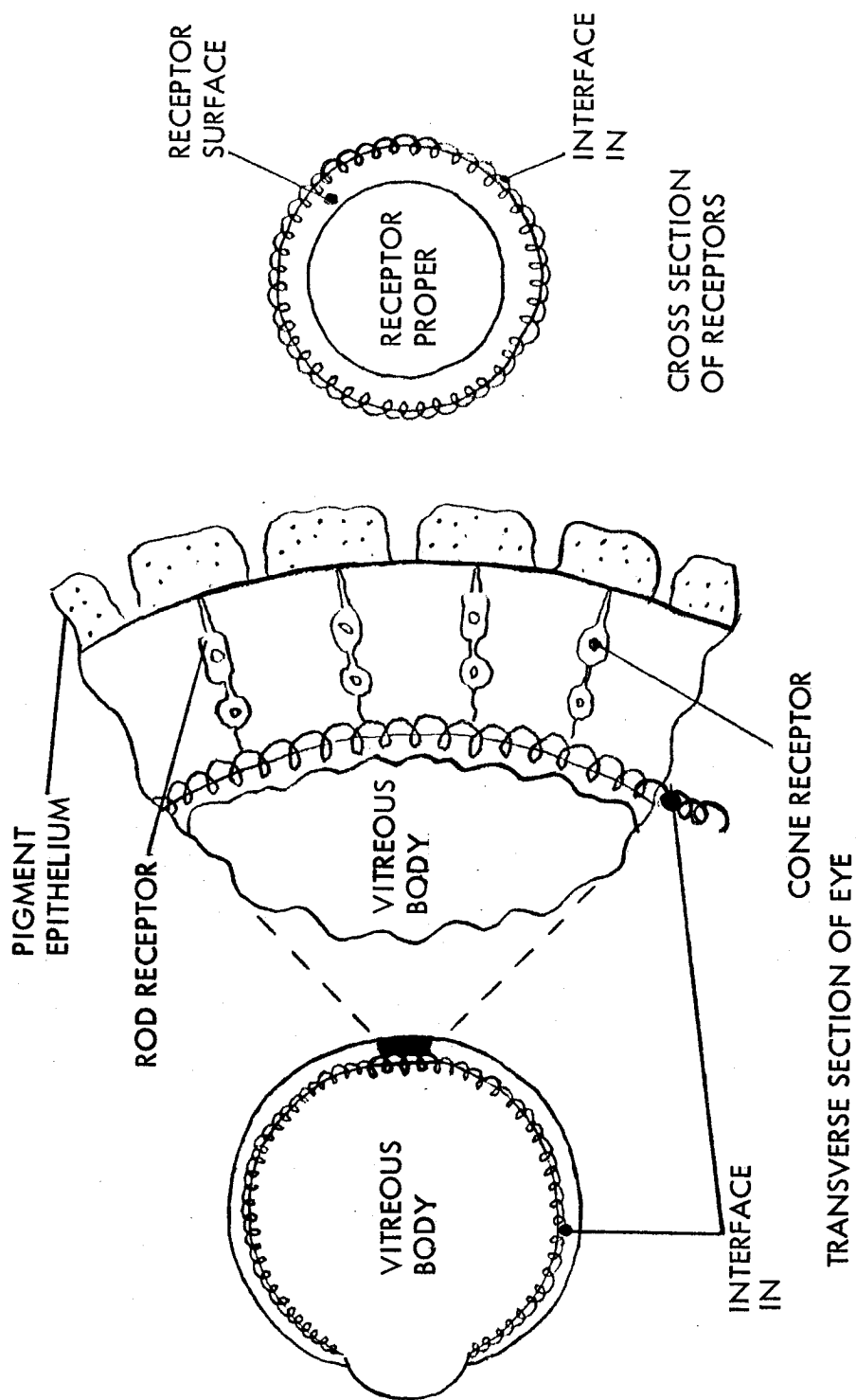
DRAWING NO.: 4-83-01-1



DISCARD NOISE FUNCTIONAL SCHEMATIC  
CROSS SECTION OF RECEPTOR  
CONFIGURATION - CONNECTION OF PARTS  
DRAWING NO: 4-83-01-1

TSC 2534

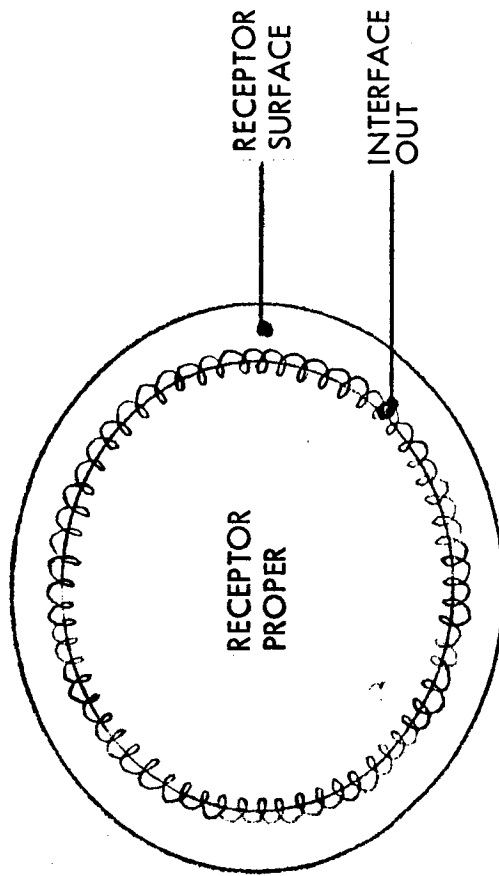
DRAWING NO. 4-83-01-2



CONFIGURATION - INTERFACE IN  
DISCARD NOISE FUNCTIONAL ASPECT  
DRAWING NO. 4-83-01-2

TSC 2532

DRAWING NO: 4-83-01-3



CONFIGURATION - INTERFACE OUT  
CROSS SECTION OF RECEPTOR  
DISCARD NOISE FUNCTIONAL ASPECT  
DRAWING NO: 4-83-01-3

TSC 2530

[illegible]

- 81 -

This group of function sheets is concerned with transmitting the information signal from the receptor surface to the receptor proper. The signal is composed of electrons that are in motion. Transmission is across the interface between the input and the distribution and control portions of the eye.

In the column labeled Object on the Function Information sheet, the electrons that are produced by the initial energy conversion in the eye are listed. The Parameter of moving electrons is velocity and the Property is magnitude and direction. Moving electrons possess the Characteristic of kinetic energy.

There is no change in energy form during transmission. Thus the Convert To column lists moving electrons that are now at the boundary of the receptor surface and receptor proper. The Method of transmission is geometrical proximity that is found when the interface is coated with electrons. Under the column labeled Mechanism, finite recapture time is listed. The Operation of transmission is, of course, the motion of electrons through the interface.

The first drawing, No. 4-84-01-1, listed on the Configuration Information sheet is the transmission functional schematic. Illustrated is the cross section of the receptor with arrows indicating that the electrons travel from the surface to the inner portion of the rods and cones.

On Drawing 4-84-01-2, the Interface In is shown to be bordered by the vitreous body and the receptor surface. The Interface Out, diagrammed on Drawing 4-84-01-3, is bounded by the receptor surface and receptor proper.

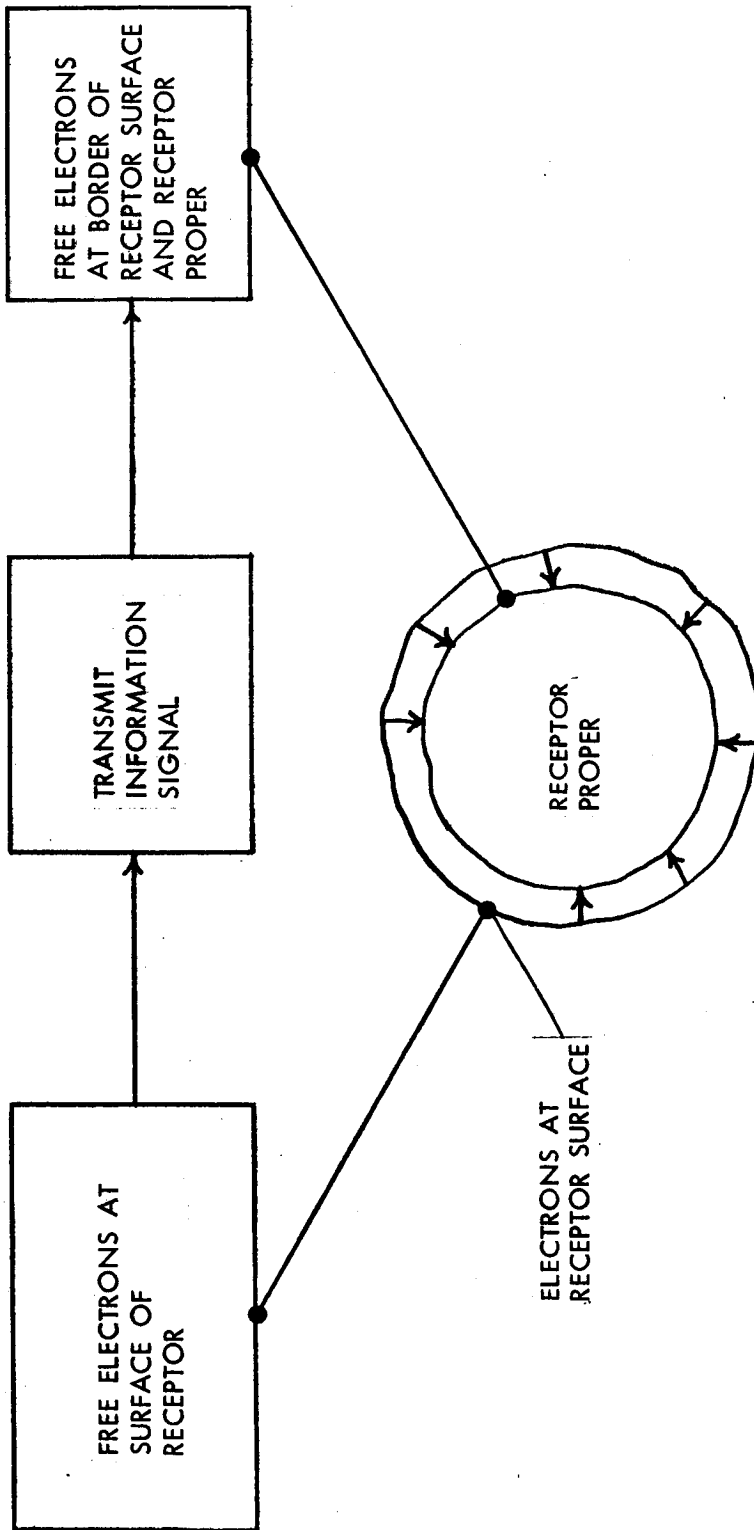
SUBSYSTEM FUNCTION			MAN																MACHINE												
			INPUT								DIST. AND CONTROL				OUTPUT				INPUT					DIST. AND CONTROL			OUTPUT				
			SENSORY					RESPIRATORY	UPPER C.I. TRACT	RADIATION	CARDIOVASCULAR	ENDOCRINE	NERVOUS	SMALL INTESTINE	MUSCULO SKELETAL	SKIN	EXCRETORY	REPRODUCTIVE	SENSORS					POWER	POWER CIRCUITS	CONTROL CIRCUITS	INFORMATION HANDLING	HEAD AND WASTE DISSIPATION	ACTUATORS	DISPLAYS	RADIATION
			VISUAL	AUDITORY	GUSTATORY	OLFACTORY	TACTILE												RADIATION	MAGNETIC	ELECTRO-STATIC	FORCE	CHEMICAL								
INPUT			01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29
DISTRIBUTION AND CONTROL	DATA	DETECT	79																												
		QUANTIZE	80																												
		QUALIFY	81																												
		TRANSDUCE	82																												
		DISCARD NOISE	83																												
		TRANSMIT INFO. SIGNAL	84																												
	POWER	ACQUIRE	85																												
		QUANTIZE	86																												
		QUALIFY	87																												
		CONVERT	88																												
		DISCARD WASTE	89																												
DISTRIBUTION AND CONTROL	DATA	ACCEPT INFO. SIGNAL	90																												
		ACCEPT INT. CONTROL SIGNAL	91																												
		CONVERT INFO. SIGNAL	92																												
		CORR. CONV. SIG. TO STORE	93																												
		CONV. STORED SIG. TO DEC.	94																												
	POWER	TRANSMIT DEC. SIGNAL	95																												
		ACQUIRE EXT. POWER	96																												
		ACCEPT INT. POWER	97																												
		CONVERT POWER TO STORE	98																												
		CORRELATE STORED POWER	99																												
OUTPUT	DATA	CONV. STORED POWER TO INPUT	100																												
		DISCARD WASTE	101																												
		ACCEPT DEC. SIGNAL	102																												
		CONVERT TO ACTION	103																												
POWER	CORR. WITH STORE	104																													
	TRANSMIT ACTION SIG.	105																													
	RETRIEVE STORED POWER	106																													
	CONV. TO ACTION	107																													
OUTPUT	POWER	CORR. WITH STORE	108																												
		TRANSMIT ACTION	109																												
SUBSYSTEM			110																												
CONFIGURATION	PARTS	SUPPORT STRUCTURE	111																												
		CONTAINER	112																												
		INTERNAL DYNAMICS	113																												
		EXTERNAL DYNAMICS	114																												
		EXTERNAL DYNAMICS	115																												
SUBSYSTEM			116																												
MATERIALS	ACCELERATABLE MASSES	117																													
	CONSTRAINED MASSES	118																													
	CHEMICAL CELLS	119																													
	RADIATION SOURCES	120																													
	PERMANENT MAGNETS	121																													
	ELECTRETS	122																													
	CONDUCTING LOOPS	123																													
	CONDUCTING SURFACES	124																													
	NON-CONDUCTORS	125																													
	SUBSYSTEM			126																											
TASKS		127																													
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		136																													

# FUNCTION INFORMATION

ELEMENT: Man, Input, Sensory, Visual															
FILE NO: 4-84-01	DEFINITION FUNCTION		OBJECT	PARA-METER	PROPERTY	CHARACT-ERISTIC	CONVERT TO	METHOD	METHOD SUB-DETAIL NO.1	METHOD SUB-DETAIL NO.2	MECH-ANISM	OPERATION	OPERATION SUB-DETAIL NO.1	OPERATION SUB-DETAIL NO.2	CHANGE WHEN TOLERABLE LIMITS ARE EXCEEDED
ASPECT:		Transmit Information Signal	moving electrons in surface of receptor	velocity	magnitude and direction	kinetic energy	moving electrons at boundary between surface and inner portion of receptor	geometrical proximity	coat interface with source of electrons		finite recapture time	motion of electrons thru interface			

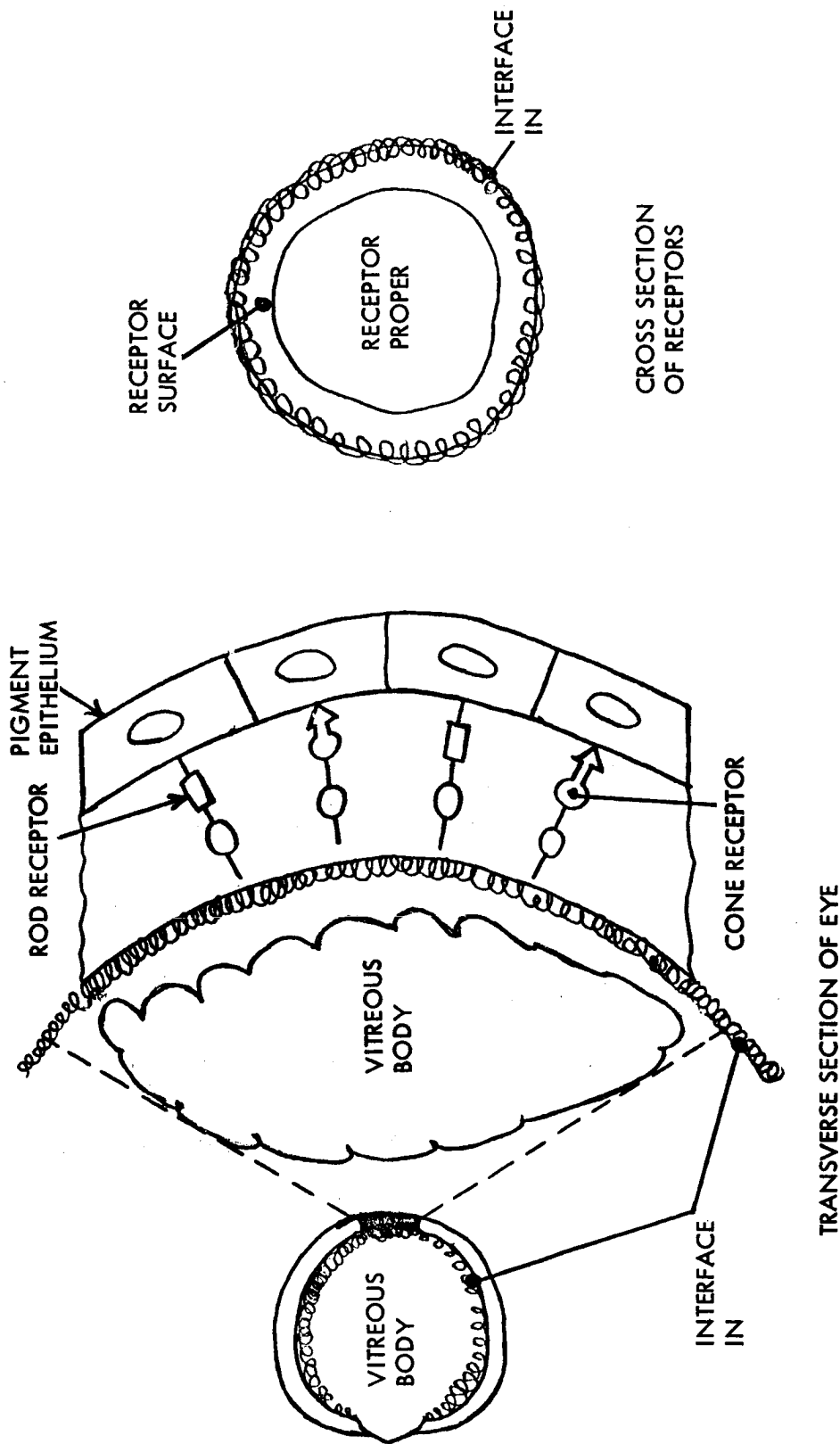
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DRAWING NO. 4-84-01-1



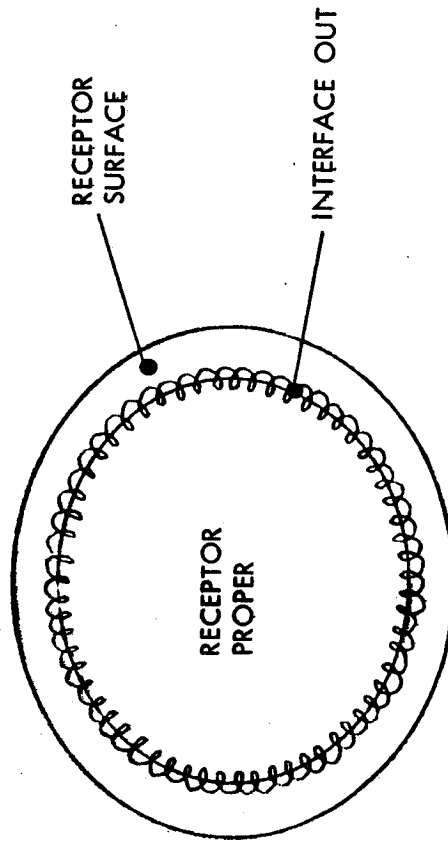
TRANSMIT INFORMATION SIGNAL FUNCTIONAL SCHEMATIC  
CROSS-SECTION OF RECEPTOR  
CONFIGURATION-CONNECTION OF PARTS

DRAWING NO. 4-84-01-1 TSC 2554



CONFIGURATION - INTERFACE IN  
TRANSMIT INFORMATION SIGNAL FUNCTIONAL ASPECT

DRAWING NO. 4-84-01-3



CONFIGURATION-INTERFACE OUT  
CROSS-SECTION OF RECEPTOR  
TRANSMIT INFORMATION SIGNAL FUNCTIONAL ASPECT

DRAWING NO. 4-84-01-3 TSC 2552

## MATERIAL INFORMATION

[illegible]

File No: 4-90-01

Acceptance of the information signal from the input portion of the eye is the topic for this group of function sheets. The information signal is composed of electrons that are moving from the interface between the input and the distribution and control segments of the eye. This interface is bordered by the receptor surface layer of cells and the receptor proper. The electrons move through this interface and are captured in the interior of the receptor. The column statements on the Function Information sheet are similar to those found under Transmit Information Signal, File No. 4-84-01 except for the Operation. In accepting the information signal, the Operation is the capture of electrons which takes place in the receptor proper.

The drawing, No. 4-90-01-1, called accept information signal functional schematic is called out on the Configuration Information sheet. On the drawing, it is shown that the electrons are accepted at the border of the receptor surface and the receptor proper. This border is the Interface In which is diagrammed on Drawing 4-90-01-2. From the interface, the electrons move into the interior of the receptor. Acceptance of the electrons is completed when the electrons penetrate the Interface Out, Drawing 4-90-01-3. The Interface Out is just inside the receptor proper.

SUBSYSTEM  FUNCTION			MAN																MACHINE												
			INPUT								DIST. AND CONTROL				OUTPUT				INPUT				DIST. AND CONTROL				OUTPUT				
			SENSORY					RESPIRATORY	UPPER G.I. TRACT	RADIATION	CARDIOVASCULAR	ENDOCRINE	NERVOUS	SMALL INTESTINE	MUSCULO SKELETAL	SKIN	EXCRETORY	REPRODUCTIVE	SENSORS				POWER	POWER CIRCUITS	CONTROL CIRCUITS	INFORMATION HANDLING	HEAD AND WAIST DISSIPATION	ACTUATORS	DISPLAYS	RADIATION	
			VISUAL	AUDITORY	GUSTATORY	OLFACTORY	TACTILE												RADIATION	MAGNETIC	ELECTRO-STATIC	FORCE									CHEMICAL
			01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29
INPUT	DATA	DETECT	79																												
		QUANTIZE	80																												
POWER		QUALIFY	81																												
		TRANSDUCE	82																												
		DISCARD NOISE	83																												
		TRANSMIT INFO. SIGNAL	84																												
		ACQUIRE	85																												
		QUANTIZE	86																												
		QUALIFY	87																												
		CONVERT	88																												
		DISCARD WASTE	89																												
		ACCEPT INFO. SIGNAL	90																												
DISTRIBUTION AND CONTROL	DATA	ACCEPT INT. CONTROL SIGNAL	91																												
		CONVERT INFO. SIGNAL	92																												
		CORR. CONV. SIG. TO STORE	93																												
		CONV. STORED SIG. TO DEC.	94																												
		TRANSMIT DEC. SIGNAL	95																												
		ACQUIRE EXT. POWER	96																												
		ACCEPT INT. POWER	97																												
		CONVERT POWER TO STORE	98																												
		CORRELATE STORED POWER	99																												
		CONV. STORED POWER TO INPUT	100																												
		DISCARD WASTE	101																												
		ACCEPT DEC. SIGNAL	102																												
OUTPUT	DATA	CONVERT TO ACTION	103																												
		CORR. WITH STORE	104																												
		TRANSMIT ACTION SIG.	105																												
		RETRIEVE STORED POWER	106																												
		CONV. TO ACTION	107																												
		CORR. WITH STORE	108																												
		TRANSMIT ACTION	109																												
SUBSYSTEM																															
CONFIGURATION			110																												
		PARTS	111																												
		SUPPORT STRUCTURE	112																												
		CONTAINER	113																												
		INTERNAL DYNAMICS	114																												
		EXTERNAL DYNAMICS	115																												
SUBSYSTEM																															
MATERIALS			116																												
		ACCELERATABLE MASSES	117																												
		CONSTRAINED MASSES	118																												
		CHEMICAL CELLS	119																												
		RADIATION SOURCES	120																												
		PERMANENT MAGNETS	121																												
		ELECTRETS	122																												
		CONDUCTING LOOPS	123																												
		CONDUCTING SURFACES	124																												
		NON-CONDUCTORS	125																												
SUBSYSTEM																															
TASKS			126																												
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			136																												

# FUNCTION INFORMATION

ELEMENT: Man, Input, Sensory, Visual												
FILE NO: 4-90-01												
DEFINITION FUNCTION	OBJECT	PARA- METER	PROPERTY	CHARACT- ERISTIC	CONVERT TO	METHOD	METHOD SUB-DETAIL NO.1	METHOD SUB-DETAIL NO.2	MECH- ANISM	OPERATION SUB-DETAIL NO.1	OPERATION SUB-DETAIL NO.2	CHANGE WHEN TOLERABLE LIMITS ARE EXCEEDED
ASPECT: Accept Information Signal	moving elec- trons at dis- tribu- tion and control inter- face	velocity	magni- tude and direc- tion	kinetic energy	moving elec- trons in recep- tor proper	geomet- rical proxi- mity			finite recap- ture time	capture of elec- trons in recep- tor proper		

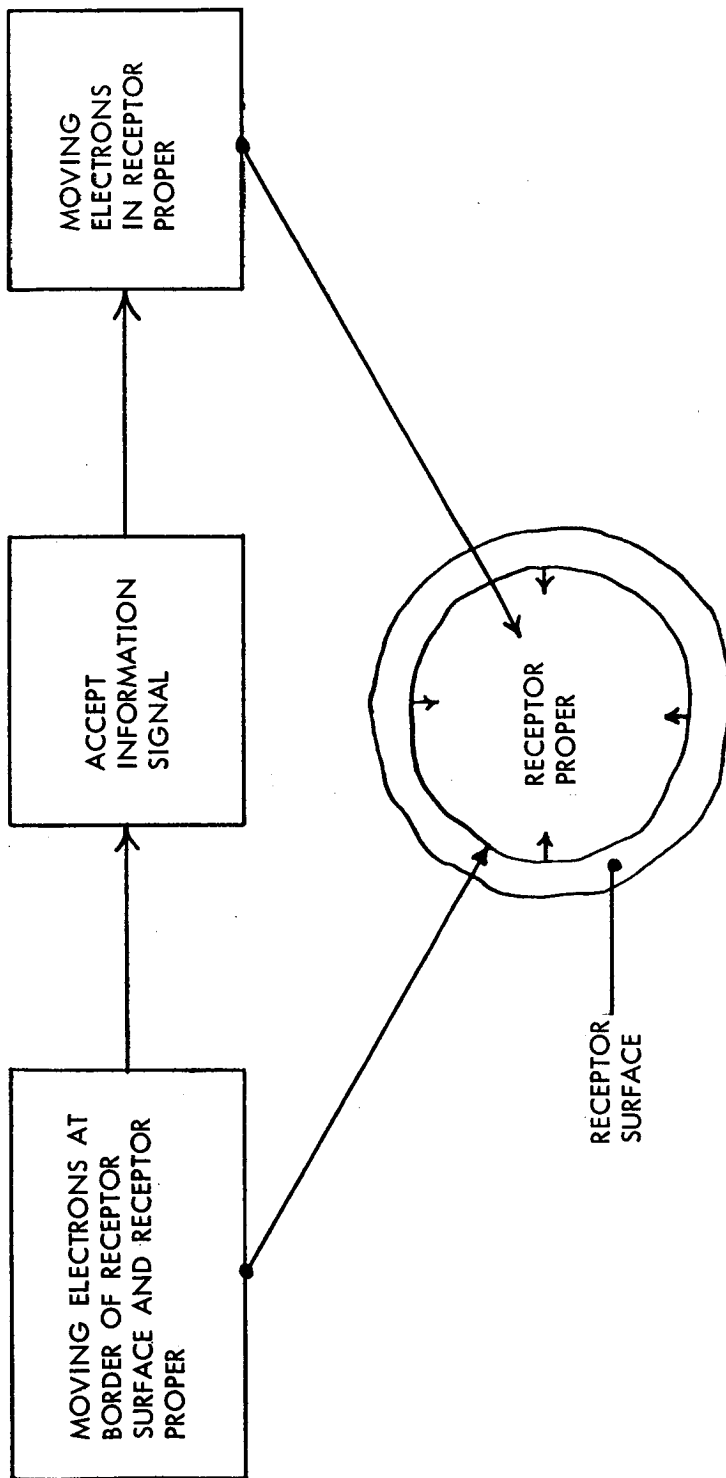
TSC1642

## CONFIGURATION INFORMATION

[illegible]

TSC 1641

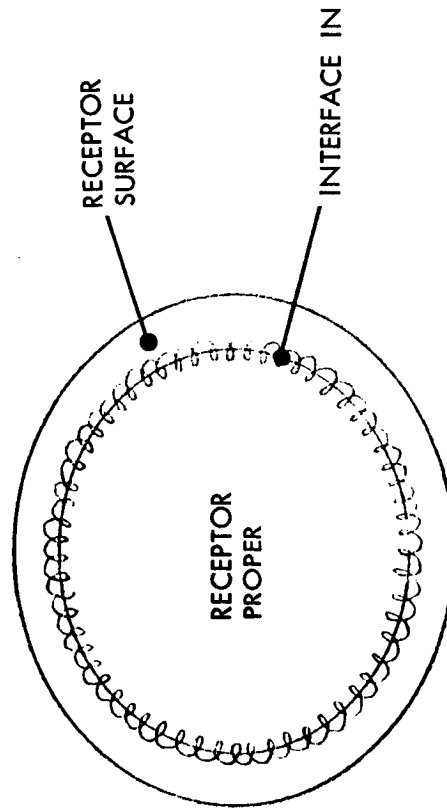
DRAWING NO. 4-90-01-1



ACCEPT INFORMATION SIGNAL FUNCTIONAL SCHEMATIC  
CROSS-SECTION OF RECEPTOR  
CONFIGURATION-CONNECTION OF PARTS

DRAWING NO. 4-90-01-1 TSC 2553

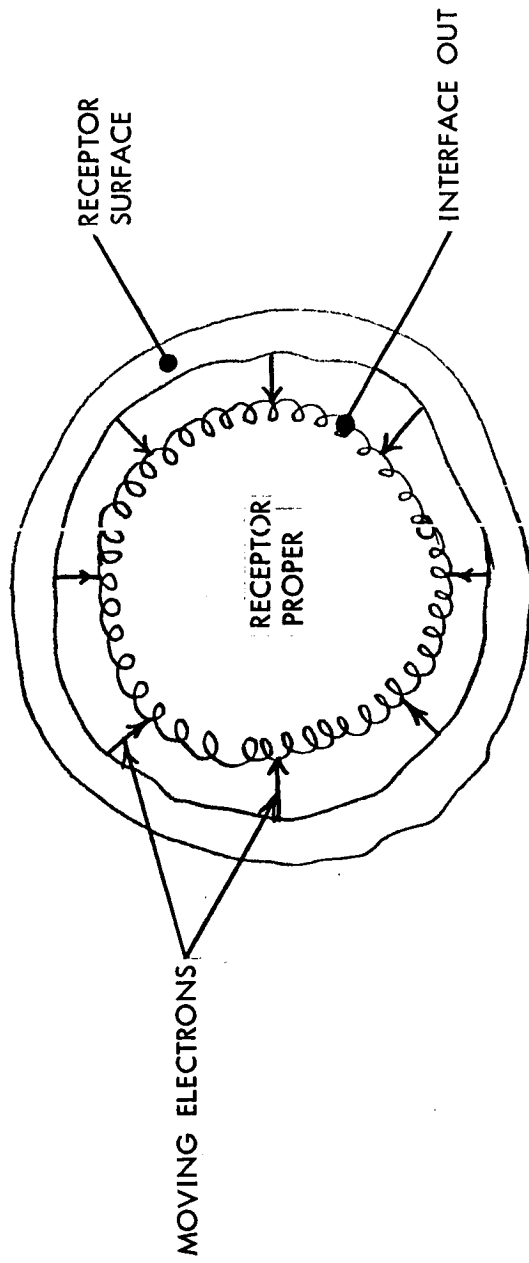
DRAWING NO. 4-90-01-2



CONFIGURATION-INTERFACE IN  
CROSS-SECTION OF RECEPTOR  
ACCEPT INFORMATION SIGNAL FUNCTIONAL ASPECT

DRAWING NO. 4-90-01-2 TSC 2551

DRAWING NO.4-90-01-3



CONFIGURATION-INTERFACE OUT  
CROSS SECTION OF RECEPTOR  
ACCEPT INFORMATION SIGNAL FUNCTIONAL ASPECT

DRAWING NO.4-90-01-3 TSC2550

[illegible]

TSC 1643

This group of information sheets deals with the internal control signals received by the distribution and control portion of the eye. An investigation of the internal control signal was carried out, and it was learned that centrifugal fibers receive these signals which are believed to originate in the brain. These signals in the form of electric pulses are accepted by the centrifugal fibers and transmitted to the centrifugal bipolar cells; then the centrifugal bipolar cells relay the electric pulse to the photoreceptors. This internal control signal may be used by the brain to produce either inhibition or facilitation of the centrifugal bipolar cell or one of its associated cells.

From the above description, the columns on the Function Information sheet may be filled out. The Object is the electric pulse that originates from the brain. The pulse is not converted to another energy form, but is transmitted along the centrifugal fiber. The Method of transmission is the absorption of ions since transverse ion flow is the mode of transmission along a nerve fiber. In the column labeled Operation, the acceptance of an electric pulse by the centrifugal fiber is listed.

On the Configuration Information sheet, the first drawing, No. 4-91-01-1, called out diagrams the flow of electric pulses to and from the centrifugal fibers. It may be seen that the internal control signal begins in the brain, moves along the centrifugal fiber and then is transmitted to the centrifugal bipolar cell.

File No: 4-91-01

The next drawing, No. 4-91-01-2, indicates that the Interface In is at the point where the brain transmits the signal to the centrifugal fiber. Drawing 4-91-01-3 shows that the Interface Out is formed by the centrifugal fiber and the centrifugal bipolar cell. Only the centrifugal fiber is listed on the Material Information sheet as the component of the eye that accepts the internal control signal.

SUBSYSTEM  FUNCTION			MAN																MACHINE													
			INPUT								DIST. AND CONTROL				OUTPUT				INPUT					DIST. AND CONTROL				OUTPUT				
			SENSORY					RESPIRATORY	UPPER G.I. TRACT	RADIATION	CARDIOVASCULAR	ENDOCRINE	NERVOUS	SMALL INTESTINE	MUSCULO SKELETAL	SKIN	EXCRETORY	REPRODUCTIVE	SENSORS					POWER	POWER CIRCUITS	CONTROL CIRCUITS	INFORMATION HANDLING	HEAD AND WASTE DISSIPATION	ACTUATORS	DISPLAYS	RADIATION	
			VISUAL	AUDITORY	GUSTATORY	OLFACTORY	TACTILE												RADIATION	MAGNETIC	ELECTRO-STATIC	FORCE	CHEMICAL									
			01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
INPUT	DATA	DETECT	79																													
		QUANTIZE	80																													
POWER		QUALIFY	81																													
		TRANSDUCE	82																													
		DISCARD NOISE	83																													
		TRANSMIT INFO. SIGNAL	84																													
		ACQUIRE	85																													
		QUANTIZE	86																													
		QUALIFY	87																													
		CONVERT	88																													
		DISCARD WASTE	89																													
		ACCEPT INFO. SIGNAL	90																													
		ACCEPT INT. CONTROL SIGNAL	91																													
		CONVERT INFO. SIGNAL	92																													
		CORR. CONV. SIG. TO STORE	93																													
		CONV. STORED SIG. TO DEC.	94																													
		TRANSMIT DEC. SIGNAL	95																													
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		ACCEPT INT. POWER	97																													
		CONVERT POWER TO STORE	98																													
		CORRELATE STORED POWER	99																													
		CONV. STORED POWER TO INPUT	100																													
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		ACCEPT DEC. SIGNAL	102																													
		CONVERT TO ACTION	103																													
		CORR. WITH STORE	104																													
		TRANSMIT ACTION SIG.	105																													
		RETRIEVE STORED POWER	106																													
		CONV. TO ACTION	107																													
		CORR. WITH STORE	108																													
		TRANSMIT ACTION	109																													
SUBSYSTEM																																
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		PARTS	111																													
		SUPPORT STRUCTURE	112																													
		CONTAINER	113																													
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		EXTERNAL DYNAMICS	115																													
SUBSYSTEM																																
MATERIALS			116																													
		ACCELERATABLE MASSES	117																													
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		CHEMICAL CELLS	119																													
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		PERMANENT MAGNETS	121																													
		ELECTRETS	122																													
		CONDUCTING LOOPS	123																													
		CONDUCTING SURFACES	124																													
		NON-CONDUCTORS	125																													
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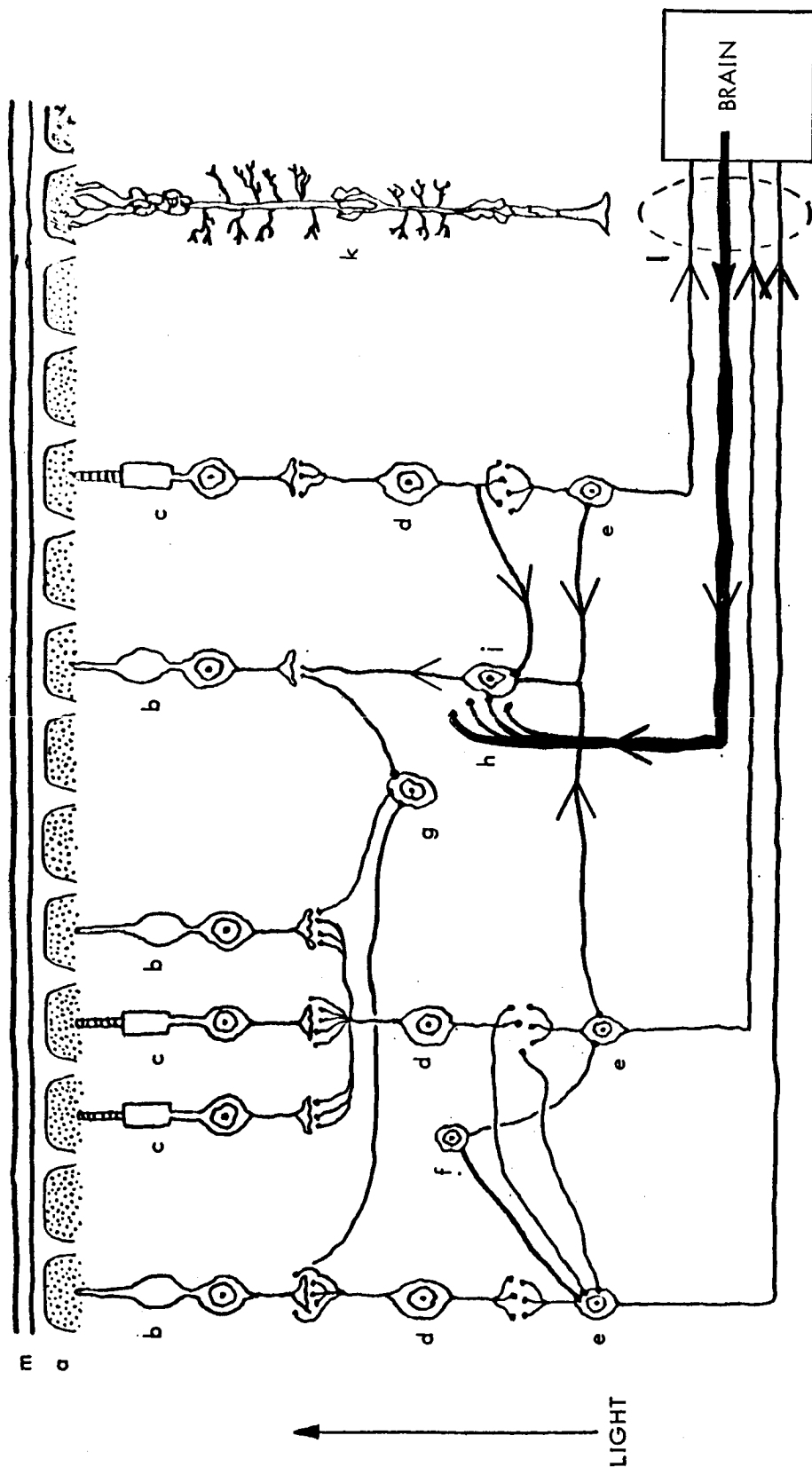
# FUNCTION INFORMATION

ELEMENT:												
FILE NO:	Man, Input, Sensory, Visual											
4-91-01												
DEFINITION FUNCTION	OBJECT	PARAMETER	PROPERTY	CHARACTERISTIC	CONVERT TO	METHOD	METHOD SUB-DETAIL NO.1	METHOD SUB-DETAIL NO.2	MECHANISM	OPERATION SUB-DETAIL NO.1	OPERATION SUB-DETAIL NO.2	CHANGE WHEN TOLERABLE LIMITS ARE EXCEEDED
ASPECT: Accept Internal Control Signal	elec- tric pulse from brain				elec- tric pulse in cen- trifugal fiber	absorp- tion of ions				accept- ance of elec- tric pulse		

TSCI642

## CONFIGURATION INFORMATION

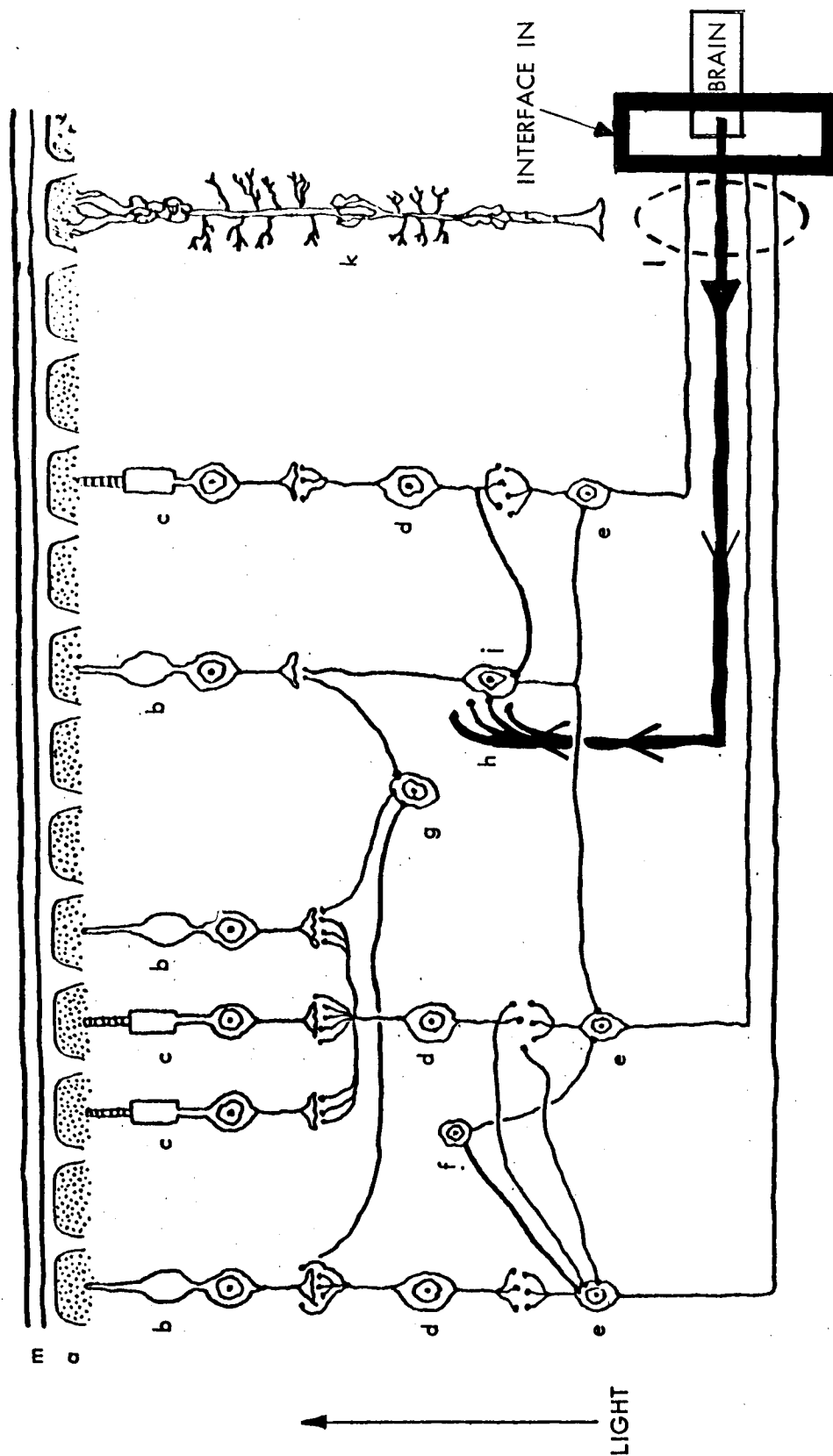
[illegible]



# THE RETINA

- a PIGMENT EPITHELIUM
- b CONE
- c ROD
- d CENTRIPETAL BIPOLAR CELL
- e GANGLION CELL
- f AMACRINE CELL
- g HORIZONTAL CELL
- h CENTRIFUGAL BIPOLAR CELL
- i CENTRIFUGAL BIPOLAR CELL
- k MULLER FIBER
- l OPTIC NERVE
- m CHOROID

FLOW OF ELECTRIC PULSES TO AND FROM CENTRIFUGAL FIBERS  
 ACCEPT INTERNAL CONTROL SIGNAL FUNCTIONAL ASPECT  
 CONFIGURATION-CONNECTION OF PARTS

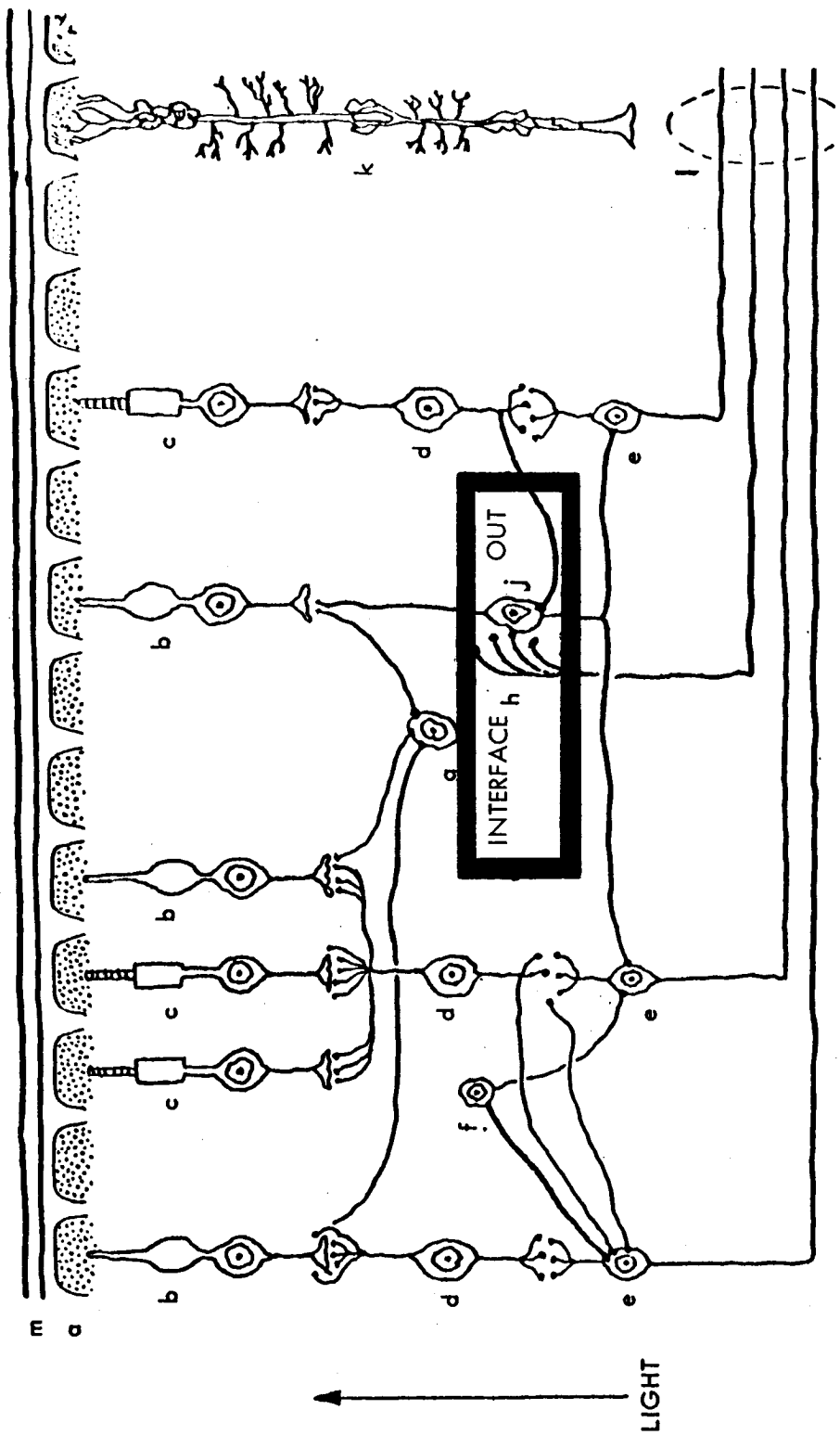


# THE RETINA

- a PIGMENT EPITHELIUM
- b CONE
- c ROD
- d CENTRIPETAL BIPOLAR CELL
- e GANGLION CELL
- f AMACRINE CELL
- g HORIZONTAL CELL
- h CENTRIFUGAL FIBER
- i CENTRIFUGAL BIPOLAR CELL
- k MULLER FIBER
- l OPTIC NERVE
- m CHOROID

CONFIGURATION-INTERFACE IN  
ACCEPT INTERNAL CONTROL SIGNAL FUNCTIONAL ASPECT

DRAWING NO. 4-91-01-2



# THE RETINA

- a PIGMENT EPITHELIUM
- b CONE
- c ROD
- d CENTRIPETAL BIPOLAR CELL
- e GANGLION CELL
- f AMACRINE CELL
- g CENTRIPETAL BIPOLAR CELL
- h INTERFACE
- i CENTRIFUGAL GANGLION CELL
- j OUT
- k MULLER FIBER
- l OPTIC NERVE
- m CHOROID

CONFIGURATION-INTERFACE OUT  
ACCEPT INTERNAL CONTROL SIGNAL FUNCTIONAL ASPECT

DRAWING NO. 4-91-01-3

## MATERIAL INFORMATION

[illegible]

The functional aspect called Convert Information Signal describes the modification of the energy of the moving electrons that have entered the interior of the receptor. On the Function Information sheet, the Object listed as the information signal is the kinetic motion of electrons. In the receptor, the energy of these electrons is used to produce electric pulses; thus, the Convert To column shows electric pulses. The Operation was the conversion of energy in the receptors.

A drawing, No. 4-92-01-1, called Convert Information Signal Functional Schematic is listed on the Configuration Information sheet. The transverse section of a receptor (rod or cone) is shown and the energy conversion is diagrammed. Next Drawing 4-92-01-2 illustrates the Interface In. At the boundary between the receptor surface and receptor proper, the conversion of the information signal begins. Drawing 4-92-01-3 indicates that the electric pulses produced in the receptors are transmitted to the centripetal bipolar, centrifugal bipolar and horizontal cells.

[illegible]

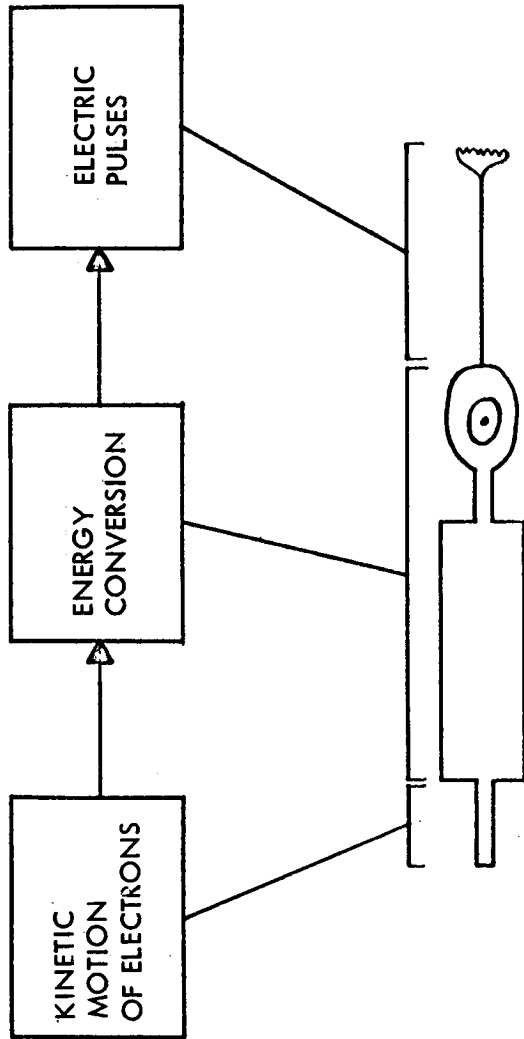
# FUNCTION INFORMATION

ELEMENT: Man, Input, Sensory, Visual												
FILE NO: 4-92-01												
DEFINITION FUNCTION	OBJECT	PARA-METER	PROPERTY	CHARACT-ERISTIC	CONVERT TO	METHOD	METHOD SUB-DETAIL NO.1	METHOD SUB-DETAIL NO.2	MECH-ANISM	OPERATION SUB-DETAIL NO.1	OPERATION SUB-DETAIL NO.2	CHANGE WHEN TOLERABLE LIMITS ARE EXCEEDED
ASPECT: Convert Information Signal	informa- tion signal, kinetic motion of elec- trons				elec- tric pulses					conver- sion of energy in recep- tor		

TSC1642



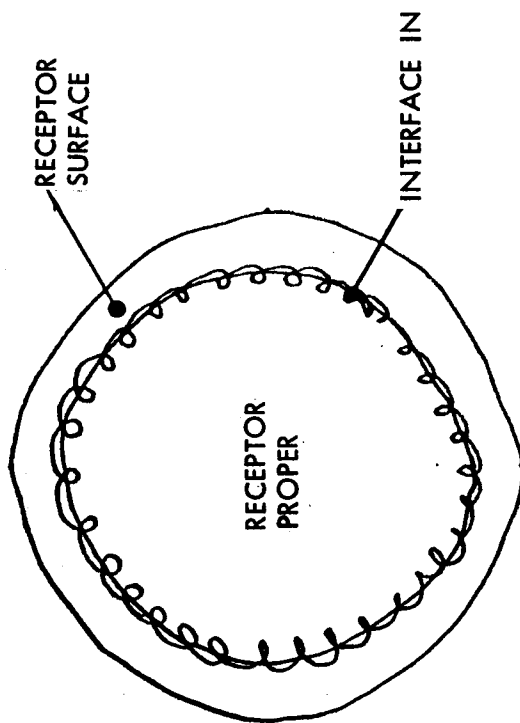
DRAWING NO. 4-92-01-1



CONVERT INFORMATION SIGNAL FUNCTIONAL SCHEMATIC  
TRANSVERSE SECTION OF RECEPTOR  
CONFIGURATION-CONNECTION OF PARTS

DRAWING NO. 4-92-01-1 TSC2548

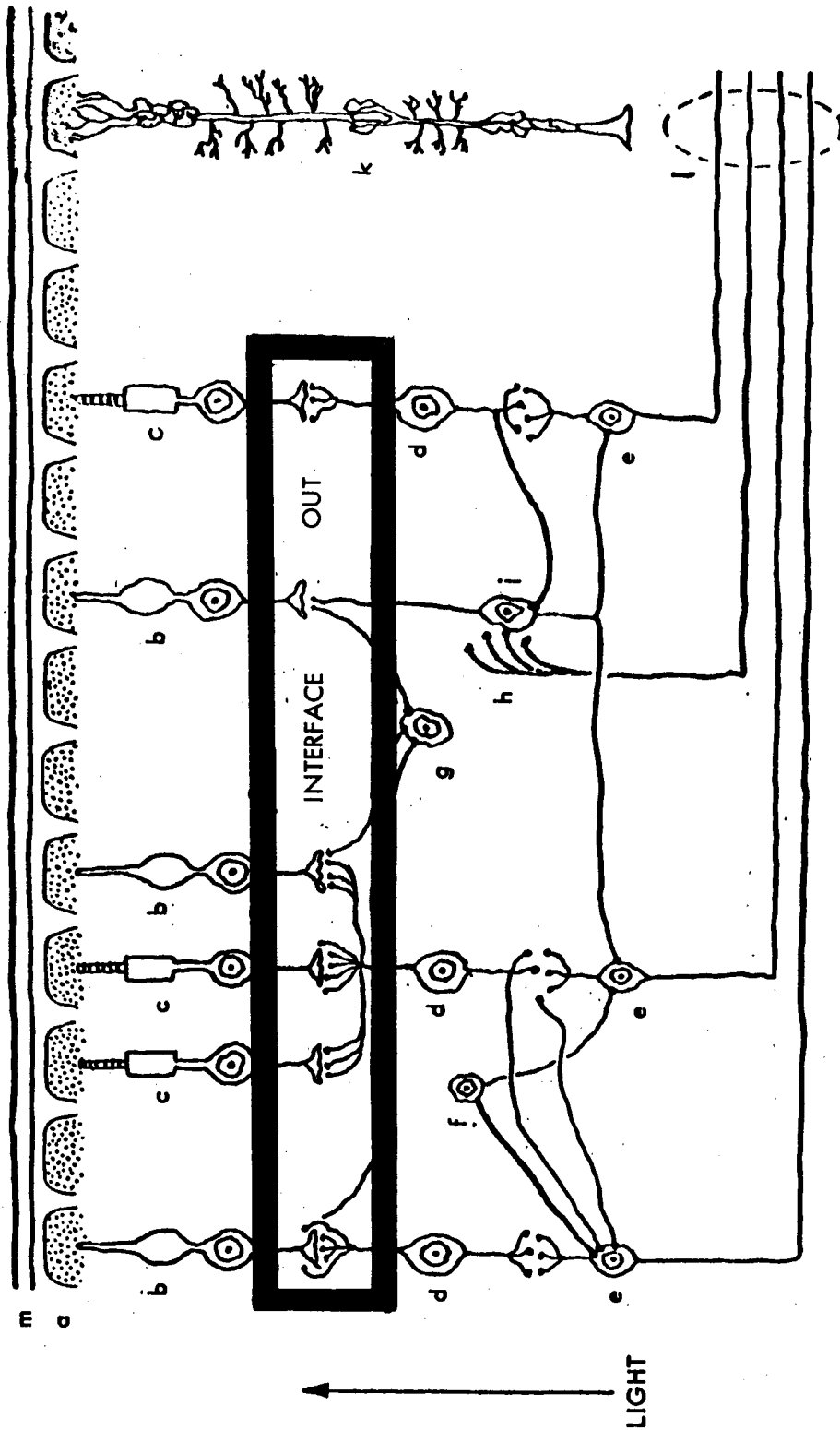
DRAWING NO. 4-92-01-2



CONFIGURATION - INTERFACE IN  
CROSS SECTION OF RECEPTORS  
CONVERT INFORMATION SIGNAL FUNCTIONAL ASPECT

DRAWING NO. 4-92-01-2

TSC 2549



# THE RETINA

- a PIGMENT EPITHELIUM
- b CONE
- c ROD
- d CENTRIPETAL BIPOLAR CELL
- e GANGLION CELL
- f AMACRINE CELL
- g HORIZONTAL CELL
- h CENTRIFUGAL FIBER
- i CENTRIFUGAL BIPOLAR CELL
- k MULLER FIBER
- l OPTIC NERVE
- m CHOROID

CONFIGURATION-INTERFACE OUT;  
 CONVERT INFORMATION SIGNAL FUNCTIONAL ASPECT

DRAWING NO. 4-92-01-3

TSC 2219E

[illegible]

**TSC 1643**

At the subsystem level no stored signal is in evidence in the distribution and control portion of the eye. Thus, the sheets explaining the correlation of the converted information signal and the stored signal do not contain details of the materials that are involved nor are any drawings under the configuration heading presented. At some lower level, the correlation of the converted signal with the stored signal can be examined.

The Function Information sheet simply outlines the aspect. Under Object, the converted information signal is listed. This signal is converted to a stored signal. The Operation is the correlation of signals.

SUBSYSTEM  FUNCTION			MAN																MACHINE													
			INPUT								DIST. AND CONTROL				OUTPUT				INPUT				DIST. AND CONTROL				OUTPUT					
			SENSORY					RESPIRATORY	UPPER G.I. TRACT	RADIATION	CARDIOVASCULAR	ENDOCRINE	NERVOUS	SMALL INTESTINE	MUSCULO SKELETAL	SKIN	EXCRETORY	REPRODUCTIVE	SENSORS					POWER	CIRCUITS CONTROL	CIRCUITS INFORMATION HANDLING	HEAD AND WAIST DISSIPATION	ACTUATORS	DISPLAYS	RADIATION		
			VISUAL	AUDITORY	GUSTATORY	OLFACTORY	TACTILE												RADIATION	MAGNETIC	ELECTRO-STATIC	FORCE	CHEMICAL									
INPUT			01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	
DISTRIBUTION AND CONTROL	DATA	DETECT	79																													
		QUANTIZE	80																													
		QUALIFY	81																													
		TRANSDUCE	82																													
		DISCARD NOISE	83																													
	POWER	TRANSMIT INFO. SIGNAL	84																													
		ACQUIRE	85																													
		QUANTIZE	86																													
		QUALIFY	87																													
		CONVERT	88																													
OUTPUT	DATA	DISCARD WASTE	89																													
		ACCEPT INFO. SIGNAL	90																													
		ACCEPT INT. CONTROL SIGNAL	91																													
		CONVERT INFO. SIGNAL	92																													
		CORR. CONV. SIG. TO STORE	93																													
	POWER	CONV. STORED SIG. TO DEC.	94																													
		TRANSMIT DEC. SIGNAL	95																													
		ACQUIRE EXT. POWER	96																													
		ACCEPT INT. POWER	97																													
		CONVERT POWER TO STORE	98																													
CONFIGURATION	DATA	CORRELATE STORED POWER	99																													
		CONV. STORED POWER TO INPUT	100																													
		DISCARD WASTE	101																													
		ACCEPT DEC. SIGNAL	102																													
		CONVERT TO ACTION	103																													
	POWER	CORR. WITH STORE	104																													
		TRANSMIT ACTION SIG.	105																													
		RETRIEVE STORED POWER	106																													
		CONV. TO ACTION	107																													
		CORR. WITH STORE	108																													
TRANSMIT ACTION	109																															
SUBSYSTEM																																
PARTS			110																													
SUPPORT STRUCTURE			111																													
CONTAINER			112																													
INTERNAL DYNAMICS			113																													
EXTERNAL DYNAMICS			114																													
SUBSYSTEM																																
MATERIALS			115																													
ACCELERATABLE MASSES			116																													
CONSTRAINED MASSES			117																													
CHEMICAL CELLS			118																													
RADIATION SOURCES			119																													
PERMANENT MAGNETS			120																													
ELECTRETS			121																													
CONDUCTING LOOPS			122																													
CONDUCTING SURFACES			123																													
NON-CONDUCTORS			124																													
SUBSYSTEM																																
TASKS			125																													
			126																													
			127																													
			128																													
			129																													
			130																													
			131																													
			132																													
			133																													
			134																													
			135																													
			136																													

# FUNCTION INFORMATION

ELEMENT: Man, Input, Sensory, Visual												
FILE NO: 4-93-01												
DEFINITION FUNCTION	OBJECT	PARAMETER	PROPERTY	CHARACTERISTIC	CONVERT TO	METHOD	METHOD SUB-DETAIL NO.1	METHOD SUB-DETAIL NO.2	MECHANISM	OPERATION SUB-DETAIL NO.1	OPERATION SUB-DETAIL NO.2	CHANGE WHEN TOLERABLE LIMITS ARE EXCEEDED
ASPECT: Correlate Converted Signal to Store	converted information signal				stored signal					correlation of signals		

TSC1642

# CONFIGURATION INFORMATION

ELEMENT: Man, Input, Sensory, Visual

FILE NO.:  
4-93-01

DRAWINGS

CONFIGURATION

ASPECT:

ARRANGEMENT  
OF  
PARTS

CONNECTION  
OF  
PARTS

DIMENSIONS

SHAPE

MOTION

DEGREES  
OF  
FREEDOM

ENVIRONMENT  
INTERFACE  
IN

ENVIRONMENT  
INTERFACE  
OUT

CHANGE WHEN  
TOLERABLE  
LIMITS ARE  
EXCEEDED

NOT

APPLICABLE

AT

SUBSYSTEM

LEVEL

[illegible]

-119-

No stored signal was found on the subsystem level in the distribution and control portion of the eye; therefore, the function that converts the stored signal to the decoded signal cannot be explained at this level. Thus the configuration and material sheets are not filled in, and the Function Information Sheet gives only a general indication of the conversion that takes place.

The Object is the stored signal which is converted to the decoded signal. It is known that the signal leaving the distribution and control portion of the eye (See File No. 4-78-01) is composed of electric pulses. These pulses, listed under the Convert To column, comprise the decoded signal. The Operation is the conversion of energy.

SUBSYSTEM  FUNCTION			MAN																MACHINE												
			INPUT								DIST. AND CONTROL				OUTPUT				INPUT				DIST. AND CONTROL				OUTPUT				
			SENSORY					RESPIRATORY	UPPER G.I. TRACT	RADIATION	CARDIOVASCULAR	ENDOCRINE	NERVOUS	SMALL INTESTINE	MUSCULO SKELETAL	SKIN	EXCRETORY	REPRODUCTIVE	SENSORS				POWER	POWER CIRCUITS	CONTROL CIRCUITS	INFORMATION HANDLING	HEAD AND WASTE DISSIPATION	ACTUATORS	DISPLAYS	RADIATION	
			VISUAL	AUDITORY	GUSTATORY	OLFACTORY	TACTILE												RADIATION	MAGNETIC	ELECTRO-STATIC	FORCE									CHEMICAL
INPUT			01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29
DATA	DETECT	79																													
		QUANTIZE	80																												
		QUALIFY	81																												
		TRANSDUCE	82																												
		DISCARD NOISE	83																												
POWER	TRANSMIT INFO. SIGNAL	84																													
	ACQUIRE	85																													
	QUANTIZE	86																													
	QUALIFY	87																													
	CONVERT	88																													
DATA	DISCARD WASTE	89																													
	ACCEPT INFO. SIGNAL	90																													
	ACCEPT INT. CONTROL SIGNAL	91																													
	CONVERT INFO. SIGNAL	92																													
	CORR. CONV. SIG. TO STORE	93																													
POWER	CONV. STORED SIG. TO DEC.	94																													
	TRANSMIT DEC. SIGNAL	95																													
	ACQUIRE EXT. POWER	96																													
	ACCEPT INT. POWER	97																													
	CONVERT POWER TO STORE	98																													
DATA	CORRELATE STORED POWER	99																													
	CONV. STORED POWER TO INPUT	100																													
	DISCARD WASTE	101																													
	ACCEPT DEC. SIGNAL	102																													
	CONVERT TO ACTION	103																													
POWER	CORR. WITH STORE	104																													
	TRANSMIT ACTION SIG.	105																													
	RETRIEVE STORED POWER	106																													
	CONV. TO ACTION	107																													
	CORR. WITH STORE	108																													
TRANSMIT ACTION	109																														
SUBSYSTEM			110																												
CONFIGURATION	PARTS	111																													
	SUPPORT STRUCTURE	112																													
	CONTAINER	113																													
	INTERNAL DYNAMICS	114																													

# FUNCTION INFORMATION

ELEMENT: Man, Input, Sensory, Visual												
FILE NO: 4-94-01												
DEFINITION FUNCTION	OBJECT	PARAMETER	PROPERTY	CHARACTERISTIC	CONVERT TO	METHOD	METHOD SUB-DETAIL NO.1	METHOD SUB-DETAIL NO.2	MECHANISM	OPERATION SUB-DETAIL NO.1	OPERATION SUB-DETAIL NO.2	CHANGE WHEN TOLERABLE LIMITS ARE EXCEEDED
ASPECT: Convert Stored Signal to Decode	stored signal				Decoded signal, electric pulse					conversion of energy		

TSCI642

# CONFIGURATION INFORMATION

ELEMENT: Man, Input, Sensory, Visual

FILE NO.: 4-94-01

DRAWINGS

CONFIGURATION

ASPECT:

ARRANGEMENT  
OF  
PARTS

CONNECTION  
OF  
PARTS

DIMENSIONS

SHAPE

MOTION

DEGREES  
OF  
FREEDOM

ENVIRONMENT  
INTERFACE  
IN

ENVIRONMENT  
INTERFACE  
OUT

CHANGE WHEN  
TOLERABLE  
LIMITS ARE  
EXCEEDED

NOT

APPLICABLE

AT

SUBSYSTEM

LEVEL

TSC 1641

# MATERIAL INFORMATION

ELEMENT: Man, Input, Sensory, Visual

FILE NO:

4-94-01

MATERIALS  
(next level)

MATERIALS

TYPE:

REMARKS:

RELATIVE  
COST

PRODUCIBILITY

AVAILABILITY

EXISTENCE

NOT

APPLICABLE

AT

SUBSYSTEM

LEVEL

TSC 1643

This group of function sheets is concerned with transmitting the decoded signal from the secondary neuron (the dendrite and nucleus of the ganglion cell) to the optic nerve (the axon of the ganglion cell). The decoded signal is formed of ions that are flowing in a transverse fashion. Signal transmission is across the interface between the distribution and control and the output portions of the eye.

The Function Information sheet is similar to the form used to describe the transmission of the information signal (4-84-01) except that the decoded signal is transmitted by means of transverse ion flow. These ions are listed in the Object and Convert To columns. As in the case of the information signal, there is no change in the energy form of the object.

A drawing, No. 4-95-01-1, diagramming the transmission is listed on the Configuration Information sheet. On the drawing, a transverse section of a ganglion cell is shown and the location of the steps in transmission are pointed out. Next, Drawing No. 4-95-01-2 diagrams the Interface In. Three types of cells are shown to transmit a signal to the ganglion cell. These are the centripetal and centrifugal bipolar cells as well as the amacrine cell. Between the Interface In and the Interface Out the transmission of ions is completed. Drawing 4-95-01-3 indicates that the Interface Out is bordered by the ganglion cell nucleus and the optic nerve.

On the Material Information sheet are listed the components of the eye that take part in the transmission of the decoded signal.

[illegible]

# FUNCTION INFORMATION

ELEMENT: Man, Input, Sensory, Visual												
FILE NO: 4-95-01												
DEFINITION FUNCTION	OBJECT	PARA- METER	PROPERTY	CHARACT- ERISTIC	CONVERT TO	METHOD	METHOD SUB-DETAIL NO.1	METHOD SUB-DETAIL NO.2	MECH- ANISM	OPERATION SUB-DETAIL NO.1	OPERATION SUB-DETAIL NO.2	CHANGE WHEN TOLERABLE LIMITS ARE EXCEEDED
ASPECT: Transmit Decoded Signal	decoded signal, concen- tions in distrib- ution and control portion of eye	concentration	potential		Ions at output inter- face of eye	geomet- rical proximi- ty	coat inter- face with source of ions		finite recom- bination time (diffu- sion)	motion of ions thru inter- face		

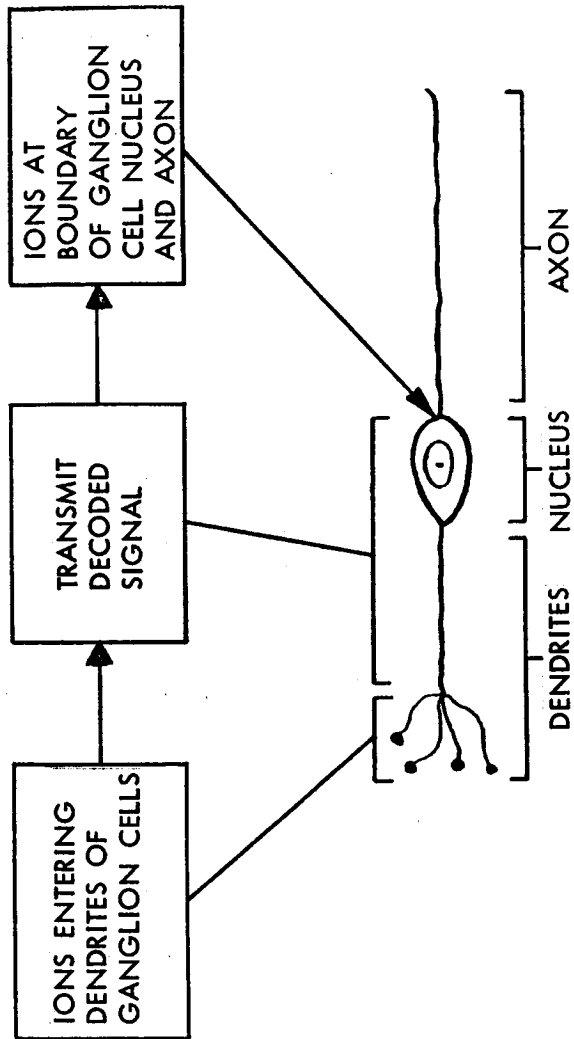
TSC1642

## CONFIGURATION INFORMATION

[illegible]

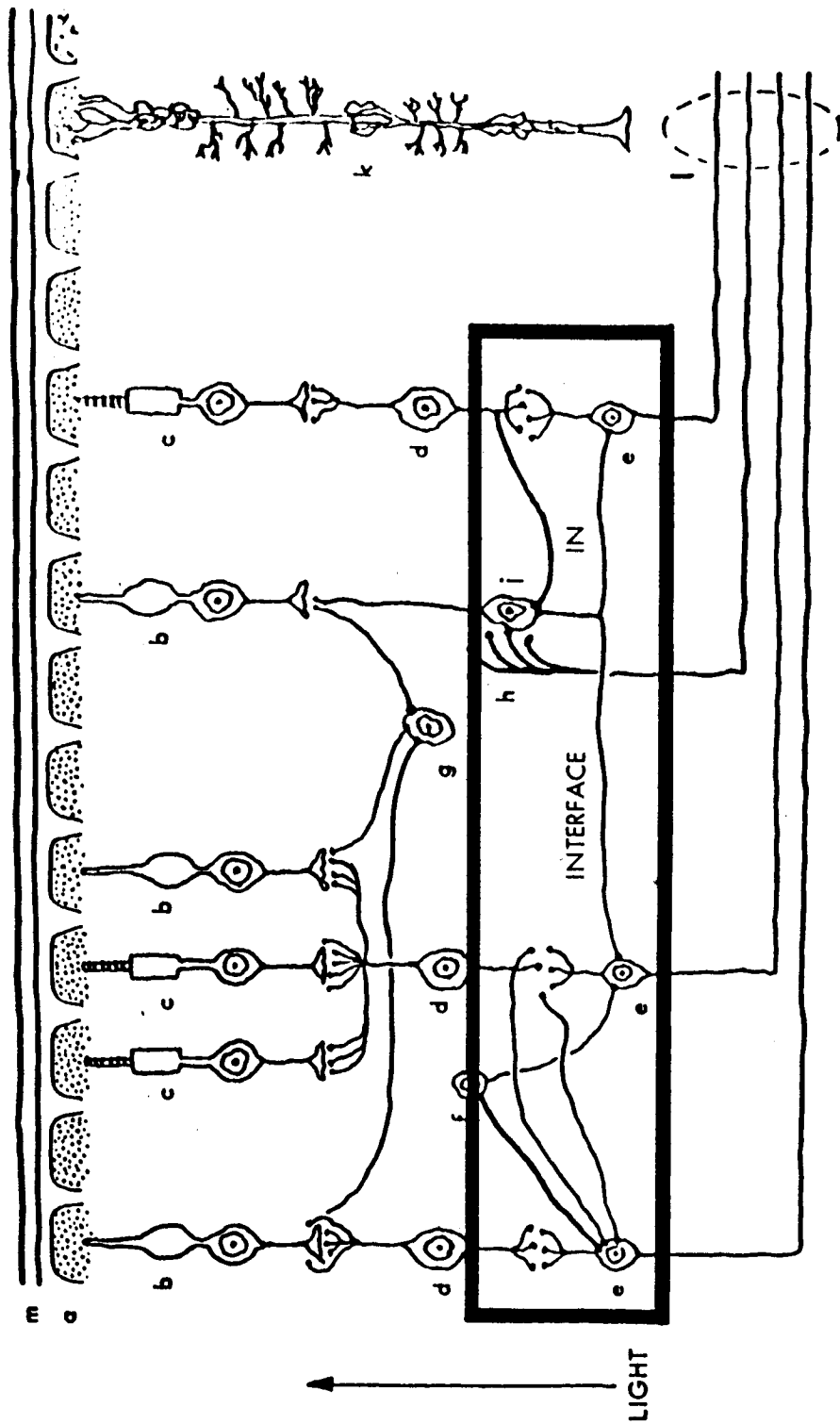
TSC 1641

DRAWING NO. 4-95-01-1



TRANSMIT DECODED SIGNAL FUNCTIONAL SCHEMATIC  
TRANSVERSE SECTION OF GANGLION CELL

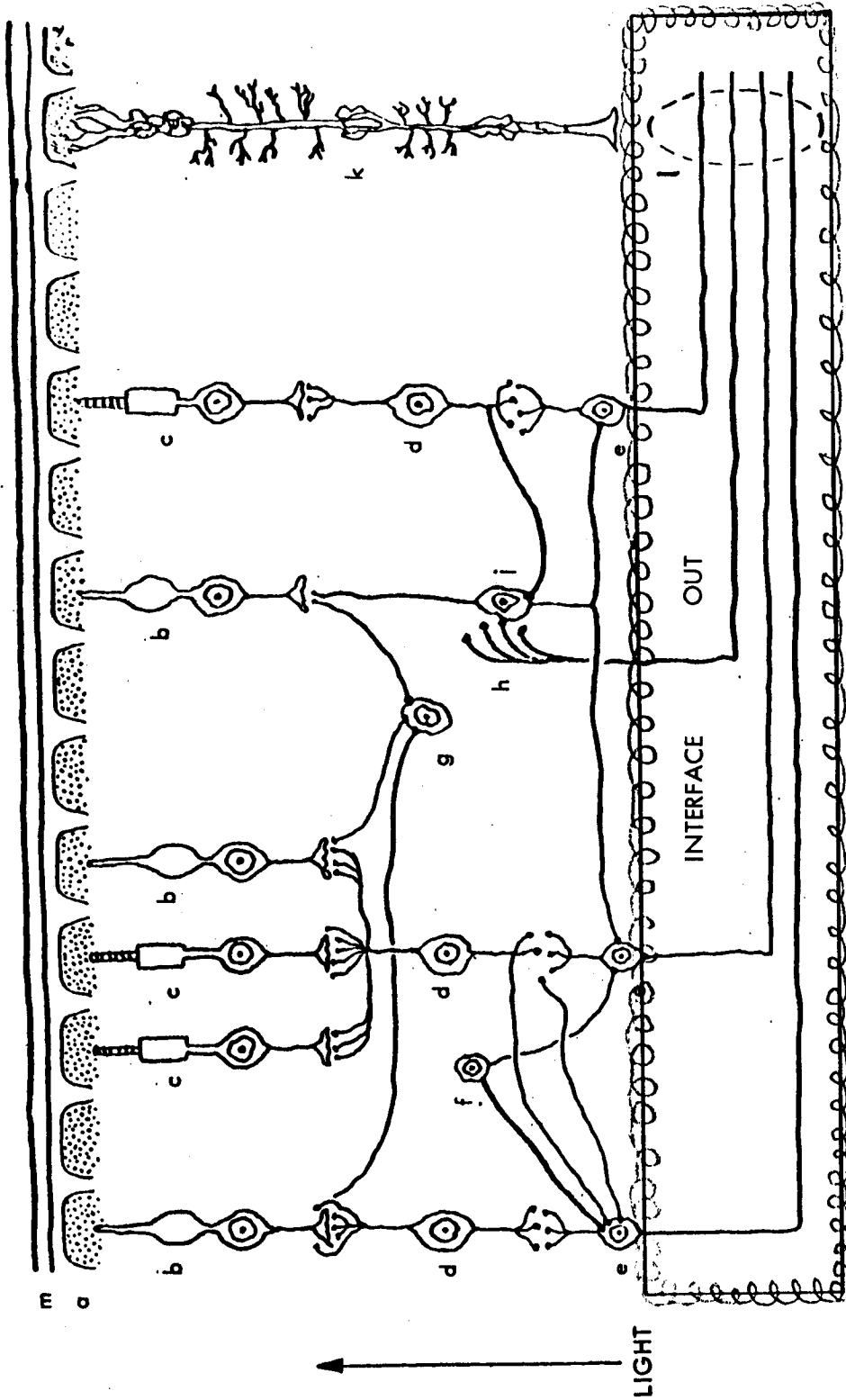
DRAWING NO. 4-95-01-1 TSC2547



# THE RETINA

- a PIGMENT EPITHELIUM
- b CONE
- c ROD
- d CENTRIPETAL BIPOLAR CELL
- e CENTRIFUGAL BIPOLAR CELL
- f AMACRINE CELL
- g HORIZONTAL CELL
- h CENTRIFUGAL FIBER
- i OPTIC NERVE
- k MULLER FIBER
- m CHOROID

CONFIGURATION-INTERFACE IN  
TRANSMIT DECODED SIGNAL FUNCTIONAL ASPECT  
DRAWING NO. 4-95-01-2



# THE RETINA

- a PIGMENT EPITHELIUM
- b CONE
- c ROD
- d CENTRIPETAL BIPOLAR CELL
- e GANGLION CELL
- f AMACRINE CELL
- g HORIZONTAL CELL
- h CENTRIFUGAL BIPOLAR CELL
- i CENTRIFUGAL BIPOLAR CELL
- k MULLER FIBER
- l OPTIC NERVE
- m CHOROID

CONFIGURATION-INTERFACE OUT  
 TRANSMIT DECODED SIGNAL FUNCTIONAL ASPECT  
 DRAWING NO. 4-95-01-3

# MATERIAL INFORMATION

ELEMENT: Man, Input, Sensory, Visual

FILE NO:

4-95-01

MATERIALS  
(next level)

MATERIALS

TYPE:

Secondary neurons

Optic nerve

REMARKS:

RELATIVE  
COST

PRODUCIBILITY

AVAILABILITY

EXISTENCE

Acceptance of the decoded signal from the distribution and control portion of the eye is the subject for this group of function sheets. The decoded signal is composed of transverse ion flow that is moving from the interface between the distribution and control and the output segments of the eye. These segments are bounded by ganglion cell nucleus (the secondary neuron) and the ganglion cell axon (the optic nerve). The statements in the columns on the Function Information sheet have been previously discussed.

On the Configuration Information sheet, it may be seen that the first drawing is Accept Decoded Signal Functional Schematic. This drawing, No. 4-102-01-1, presents a transverse section of a ganglion cell and indicates the location of the ions that are accepted. Following this figure is Drawing 4-102-01-2 that shows the Interface In. The interface is bounded by the ganglion cell nucleus and the ganglion cell axon. The final drawing, No. 4-102-01-3, in the file depicts the Interface Out. It is shown that this interface is bordered by the ganglion cell axon (optic nerve) and the lateral geniculate bodies which are the first neurons of the nervous subsystem that the eye excites. Each optic nerve fiber stimulates five or six lateral geniculate neuron cells.

The Material Information sheet lists the ganglion cell and the optic nerve as the components involved in the acceptance of ions.

[illegible]

# FUNCTION INFORMATION

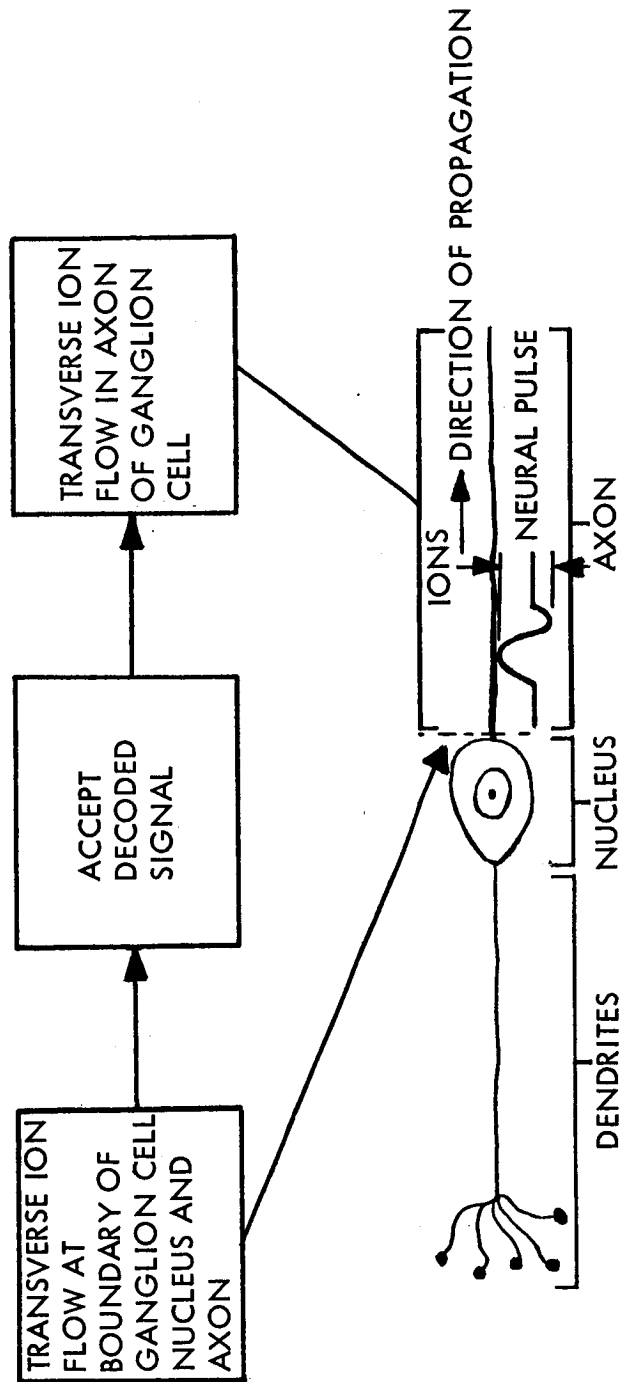
ELEMENT: Man, Input, Sensory, Visual												
FILE NO: 4-102-01												
DEFINITION FUNCTION	OBJECT	PARAMETER	PROPERTY	CHARACTERISTIC	CONVERT TO	METHOD	METHOD SUB-DETAIL NO.1	METHOD SUB-DETAIL NO.2	MECHANISM	OPERATION SUB-DETAIL NO.1	OPERATION SUB-DETAIL NO.2	CHANGE WHEN TOLERABLE LIMITS ARE EXCEEDED
ASPECT: Accept Decoded Signal	Ions at Output Inter- face of eye (Nucleus -axon region of gang- lion cell)	Concen- tration	Poten- tial		Ions in axon of gang- lion cell	Geome- trical proxi- mity			Neural con- duction	Propa- gation of trans- verse ion flow in axon of gang- lion cell		

TSC1642

## CONFIGURATION INFORMATION

[illegible]

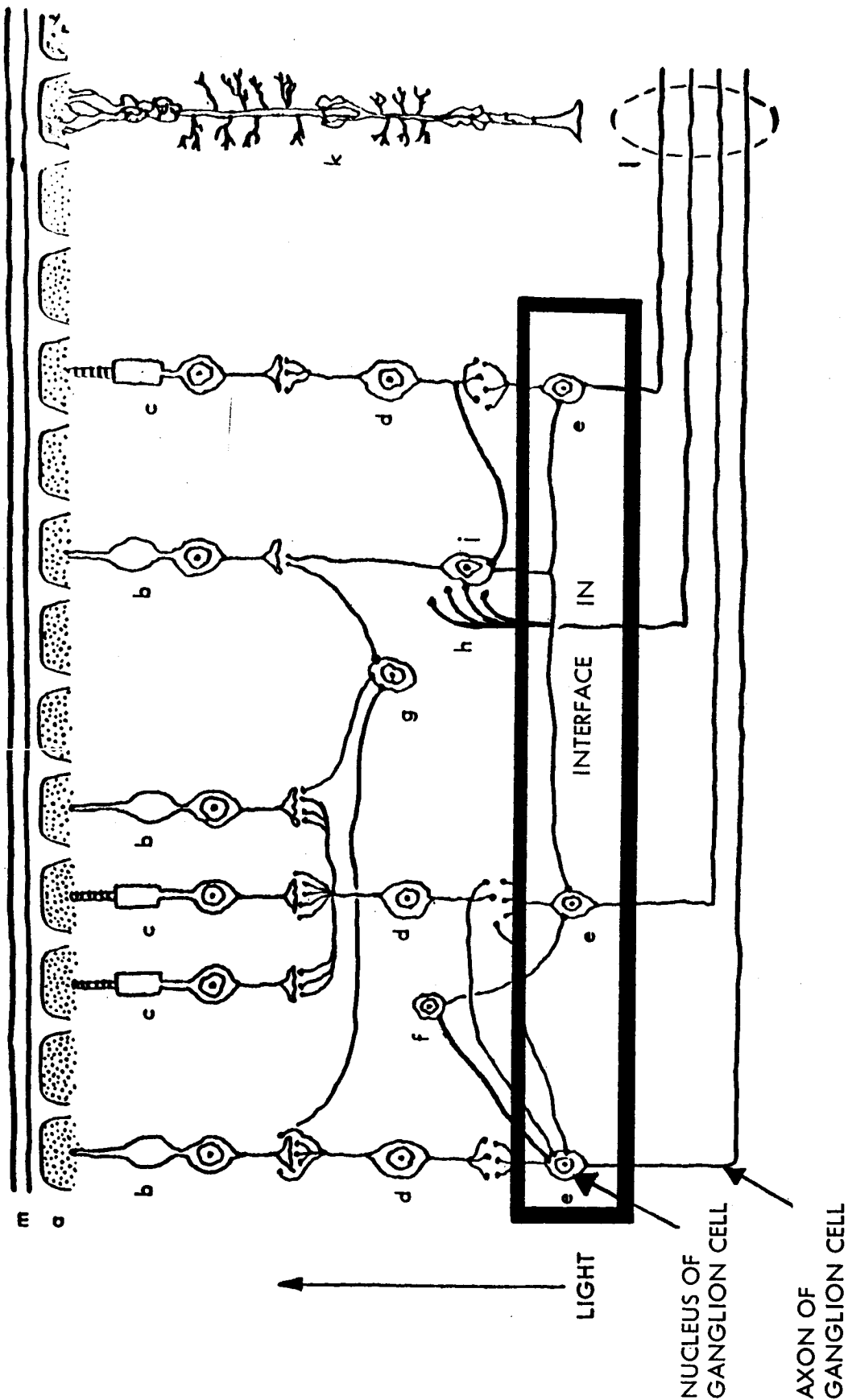
DRAWING NO: 4-102-01-1



ACCEPT DECODED SIGNAL FUNCTIONAL SCHEMATIC  
TRANSVERSE SECTION OF GANGLION CELL

DRAWING NO: 4-102-01-1

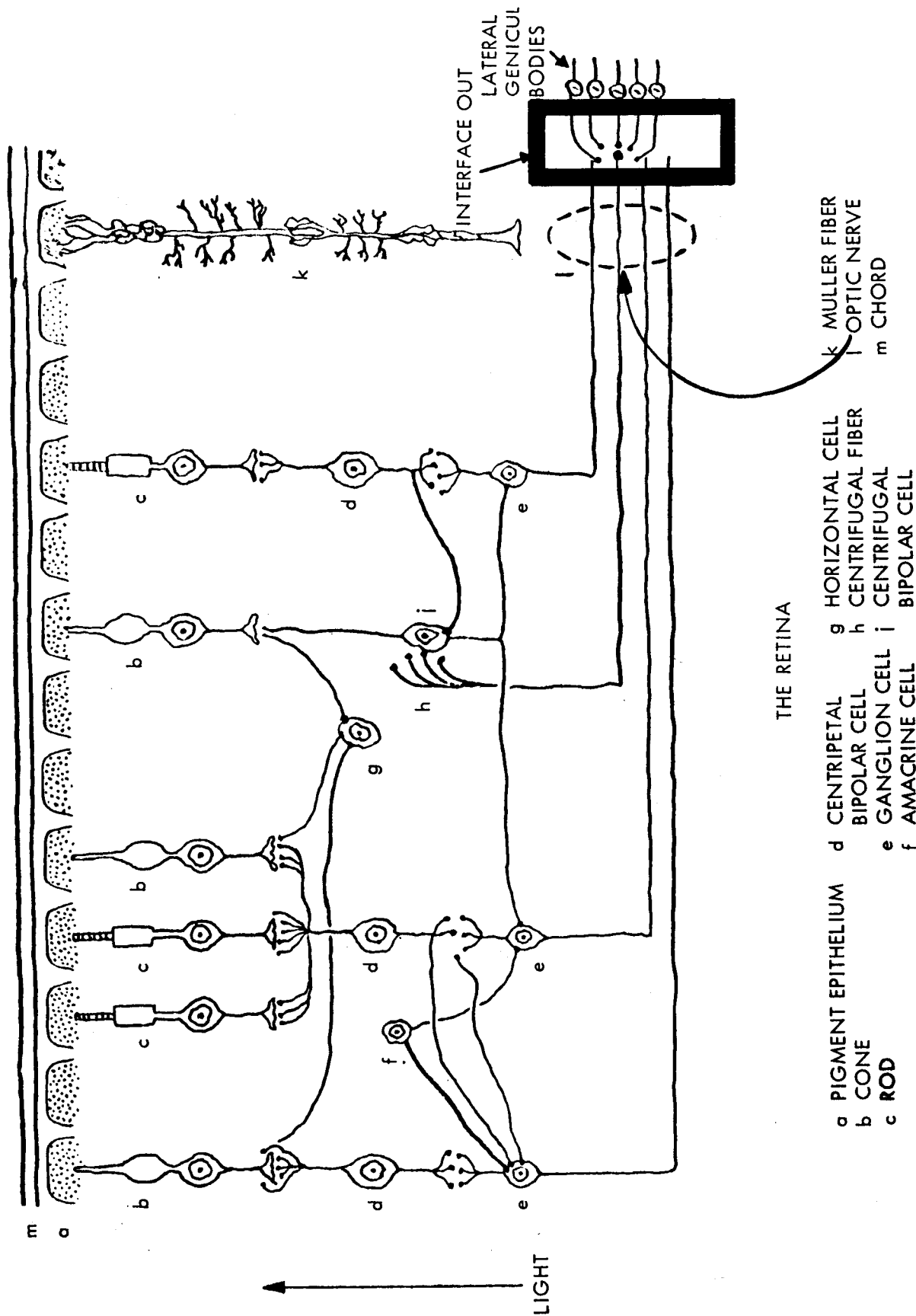
TSC 2546



# THE RETINA

- a PIGMENT EPITHELIUM
- b CONE
- c ROD
- d CENTRIPETAL BIPOLAR CELL
- e GANGLION CELL
- f AMACRINE CELL
- g HORIZONTAL CELL
- h CENTRIFUGAL FIBER
- i CENTRIFUGAL BIPOLAR CELL
- k MULLER FIBER
- l OPTIC NERVE
- m CHORD

CONFIGURATION-INTERFACE IN  
 ACCEPT DECODED SIGNAL FUNCTIONAL ASPECT  
 DRAWING NO. 4-102-01-2



# MATERIAL INFORMATION

ELEMENT: Man, Input, Sensory, Visual

FILE NO:

4-102-01

MATERIALS  
(next level)

MATERIALS

TYPE:

REMARKS:

RELATIVE  
COST

PRODUCIBILITY

AVAILABILITY

EXISTENCE

ganglion cell

nucleus

axon of ganglion  
cell (optic nerve)

TSC 1643

File No: 4-103-01

The functional aspect covers the conversion of the decoded signal to the action signal. Examination of the optic nerve indicates that the decoded signal entering is composed of neural pulses and the exiting action signal is also pulses. Thus the Object and Convert To columns on the Function Information sheet both list neural pulses.

As the Configuration Information sheet indicates, the location of the conversion from decoded to action signal takes place within the optic nerve; therefore, no drawings of the Interface In and Interface Out were made.

The only component shown on the Material Information sheet is the optic nerve.

SUBSYSTEM FUNCTION			MAN																MACHINE												
			INPUT								DIST. AND CONTROL				OUTPUT				INPUT					DIST. AND CONTROL			OUTPUT				
			SENSORY					RESPIRATORY	UPPER G.I. TRACT	RADIATION	CARDIOVASCULAR	ENDOCRINE	NERVOUS	SMALL INTESTINE	MUSCULO SKELETAL	SKIN	EXCRETORY	REPRODUCTIVE	SENSORS					POWER	POWER CIRCUITS	CONTROL CIRCUITS	INFORMATION HANDLING	HEAD AND WASTE DISSIPATION	ACTUATORS	DISPLAYS	RADIATION
			VISUAL	AUDITORY	GUSTATORY	OLFACATORY	TACTILE												RADIATION	MAGNETIC	ELECTRO-STATIC	FORCE	CHEMICAL								
			01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29
INPUT	DATA	DETECT	79																												
		QUANTIZE	80																												
		QUALIFY	81																												
		TRANSDUCE	82																												
		DISCARD NOISE	83																												
	POWER	TRANSMIT INFO. SIGNAL	84																												
		ACQUIRE	85																												
		QUANTIZE	86																												
		QUALIFY	87																												
		CONVERT	88																												
DISTRIBUTION AND CONTROL	DATA	DISCARD WASTE	89																												
		ACCEPT INFO. SIGNAL	90																												
		ACCEPT INT. CONTROL SIGNAL	91																												
		CONVERT INFO. SIGNAL	92																												
		CORR. CONV. SIG. TO STORE	93																												
	POWER	CONV. STORED SIG. TO DEC.	94																												
		TRANSMIT DEC. SIGNAL	95																												
		ACQUIRE EXT. POWER	96																												
		ACCEPT INT. POWER	97																												
		CONVERT POWER TO STORE	98																												
OUTPUT	DATA	CORRELATE STORED POWER	99																												
		CONV. STORED POWER TO INPUT	100																												
		DISCARD WASTE	101																												
		ACCEPT DEC. SIGNAL	102																												
		CONVERT TO ACTION	103																												
POWER	CORR. WITH STORE	104																													
	TRANSMIT ACTION SIG.	105																													
	RETRIEVE STORED POWER	106																													
	CONV. TO ACTION	107																													
	CORR. WITH STORE	108																													
TRANSMIT ACTION	109																														
SUBSYSTEM			110																												
CONFIGURATION			111																												
		PARTS	112																												
		SUPPORT STRUCTURE	113																												
		CONTAINER	114																												
		INTERNAL DYNAMICS	115																												
		EXTERNAL DYNAMICS	116																												
SUBSYSTEM			117																												
MATERIALS			118																												
		ACCELERATABLE MASSES	119																												
		CONSTRAINED MASSES	120																												
		CHEMICAL CELLS	121																												
		RADIATION SOURCES	122																												
		PERMANENT MAGNETS	123																												
		ELECTRETS	124																												
		CONDUCTING LOOPS	125																												
		CONDUCTING SURFACES	126																												
		NON-CONDUCTORS	127																												
		SUBSYSTEM			128																										
TASKS			129																												
			130																												
			131																												
			132																												
			133																												
			134																												
			135																												
			136																												

# FUNCTION INFORMATION

ELEMENT: Man, Input, Sensory, Visual												
FILE NO: 4-103-01												
DEFINITION FUNCTION	OBJECT	PARA-METER	PROPERTY	CHARACT-ERISTIC	CONVERT TO	METHOD	METHOD SUB-DETAIL NO.1	METHOD SUB-DETAIL NO.2	MECH-ANISM	OPERATION SUB-DETAIL NO.1	OPERATION SUB-DETAIL NO.2	CHANGE WHEN TOLERABLE LIMITS ARE EXCEEDED
ASPECT: Convert to action	decoded signal-neural pulses				action signal-neural pulses					propa-gation of signal		

TSCI642

# CONFIGURATION INFORMATION

ELEMENT: Man, Input, Sensory, Visual

FILE NO.:

4-103-01

DRAWINGS

CONFIGURATION

ASPECT:

ARRANGEMENT  
OF  
PARTS

CONNECTION  
OF  
PARTS

DIMENSIONS

SHAPE

MOTION

DEGREES  
OF  
FREEDOM

ENVIRONMENT  
INTERFACE  
IN

ENVIRONMENT  
INTERFACE  
OUT

CHANGE WHEN  
TOLERABLE  
LIMITS ARE  
EXCEEDED

# MATERIAL INFORMATION

ELEMENT: Man, Input, Sensory, Visual

FILE NO:

4-103-01

MATERIALS  
(next level)

MATERIALS

TYPE:

Optic nerve

REMARKS:

RELATIVE  
COST

PRODUCIBILITY

AVAILABILITY

EXISTENCE

This functional aspect is concerned with correlating the stored signal with the action signal. At the subsystem level, no correlation of the action signal with a stored signal is apparent. The Function Information sheet only contains a statement that this correlation takes place, but no details are supplied. This sheet indicates that the Object is the action signal which undergoes correlation, but does not change in energy form.

On the Configuration Information sheet, both the Interface In and Out are shown to be internal to the optic nerve. This indicates that the correlation of the action signal with the stored signal takes place within the optic nerve.

SUBSYSTEM FUNCTION			MAN																MACHINE																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																					
			INPUT								DIST. AND CONTROL				OUTPUT				INPUT					DIST. AND CONTROL			OUTPUT																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																													
			SENSORY					RESPIRATORY	UPPER G.I. TRACT	RADIATION	CARDIOVASCULAR	ENDOCRINE	NERVOUS	SMALL INTESTINE	MUSCULO SKELETAL	SKIN	EXCRETORY	REPRODUCTIVE	SENSORS					POWER	POWER CIRCUITS	CONTROL CIRCUITS	INFORMATION HANDLING	HEAD AND WASTE DISSIPATION	ACTUATORS	DISPLAYS	RADIATION																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																									
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# FUNCTION INFORMATION

FILE NO: 4-104-01		ELEMENT: Man, Input, Sensory, Visual										
<div>DEFINITION</div> <div>FUNCTION</div>	OBJECT	PARAMETER	PROPERTY	CHARACTERISTIC	CONVERT TO	METHOD	METHOD SUB-DETAIL NO.1	METHOD SUB-DETAIL NO.2	MECHANISM	OPERATION SUB-DETAIL NO.1	OPERATION SUB-DETAIL NO.2	CHANGE WHEN TOLERABLE LIMITS ARE EXCEEDED
	<div>ASPECT:</div> <div>Correlate with store</div>	action signal			action signal						correlation of signal	

TSC1642

## CONFIGURATION INFORMATION

[illegible]

# MATERIAL INFORMATION

ELEMENT: Man, Input, Sensory, Visual

FILE NO:

4-104-01

MATERIALS  
(next level)

MATERIALS

TYPE:

optic nerve

REMARKS:

RELATIVE  
COST

PRODUCIBILITY

AVAILABILITY

EXISTENCE

This functional aspect discusses the transmission of the action signal from the output portion of the eye to the first neuron encountered in the nervous subsystem. The column labeled Object on the Function Information sheet lists the electric pulses in the optic nerve. These pulses compose the action signal in the output portion of the eye.

The functional aspect of transmission does not alter the energy form of the object and thus the Convert To column lists electric pulses that have entered the lateral geniculate bodies. Under the column headed Operation, the spacial displacement of the electric pulse is mentioned.

The first drawing, No. 4-105-01-1, listed on the Configuration Information Sheet is titled Transmit Action Signal Functional Schematic. Transverse sections of a ganglion cell and a number of lateral geniculate bodies are shown. On the second drawing, No. 4-105-01-2, in this file, the Interface In is shown. Bordering the interface are the nucleus of the ganglion cell and the axon of the ganglion cell (optic nerve). The other end of the optic nerve forms one of the boundaries of the Interface Out diagrammed on Drawing 4-105-01-3. The other components of the boundary are the lateral geniculate bodies.

On the Material Information sheet, the components of the eye involved in the transmission of the action signal are listed.

SUBSYSTEM  FUNCTION			MAN																MACHINE												
			INPUT								DIST. AND CONTROL				OUTPUT				INPUT					DIST. AND CONTROL			OUTPUT				
			SENSORY					RESPIRATORY	UPPER G.I. TRACT	RADIATION	CARDIOVASCULAR	ENDOCRINE	NERVOUS	SMALL INTESTINE	MUSCULO SKELETAL	SKIN	EXCRETORY	REPRODUCTIVE	SENSORS				POWER	POWER CIRCUITS	CONTROL CIRCUITS	INFORMATION HANDLING	HEAD AND WASTE DISSIPATION	ACTUATORS	DISPLAYS	RADIATION	
			VISUAL	AUDITORY	GUSTATORY	OLFACTORY	TACTILE												RADIATION	MAGNETIC	ELECTRO-STATIC	FORCE									CHEMICAL
INPUT			01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29
DISTRIBUTION AND CONTROL	DATA	DETECT	79																												
		QUANTIZE	80																												
		QUALIFY	81																												
		TRANSDUCE	82																												
		DISCARD NOISE	83																												
	POWER	TRANSMIT INFO. SIGNAL	84																												
		ACQUIRE	85																												
		QUANTIZE	86																												
		QUALIFY	87																												
		CONVERT	88																												
OUTPUT	DATA	DISCARD WASTE	89																												
		ACCEPT INFO. SIGNAL	90																												
		ACCEPT INT. CONTROL SIGNAL	91																												
		CONVERT INFO. SIGNAL	92																												
		CORR. CONV. SIG. TO STORE	93																												
	POWER	CONV. STORED SIG. TO DEC.	94																												
		TRANSMIT DEC. SIGNAL	95																												
		ACQUIRE EXT. POWER	96																												
		ACCEPT INT. POWER	97																												
		CONVERT POWER TO STORE	98																												
DISTRIBUTION AND CONTROL <td>CORRELATE STORED POWER</td> <td>99</td> <td></td> <td></td> <td></td> <td></td> <td></td> <td></td> <td></td> <td></td> <td></td> <td></td> <td></td> <td></td> <td></td> <td></td> <td></td> <td></td> <td></td> <td></td> <td></td> <td></td> <td></td> <td></td> <td></td> <td></td> <td></td> <td></td> <td></td> <td></td>	CORRELATE STORED POWER	99																													
	CONV. STORED POWER TO INPUT	100																													
	DISCARD WASTE	101																													
	ACCEPT DEC. SIGNAL	102																													
	CONVERT TO ACTION	103																													
OUTPUT	POWER	CORR. WITH STORE	104																												
		TRANSMIT ACTION SIG.	105																												
		RETRIEVE STORED POWER	106																												
		CONV. TO ACTION	107																												
		CORR. WITH STORE	108																												
TRANSMIT ACTION	109																														
SUBSYSTEM																															
CONFIGURATION			110																												
SUBSYSTEM	PARTS	111																													
	SUPPORT STRUCTURE	112																													
	CONTAINER	113																													
	INTERNAL DYNAMICS	114																													
	EXTERNAL DYNAMICS	115																													
SUBSYSTEM																															
MATERIALS			116																												
SUBSYSTEM	ACCELERATABLE MASSES	117																													
	CONSTRAINED MASSES	118																													
	CHEMICAL CELLS	119																													
	RADIATION SOURCES	120																													
	PERMANENT MAGNETS	121																													
	ELECTRETS	122																													
	CONDUCTING LOOPS	123																													
	CONDUCTING SURFACES	124																													
	NON-CONDUCTORS	125																													
	SUBSYSTEM																														
TASKS			126																												
SUBSYSTEM		127																													
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		135																													
		136																													

# FUNCTION INFORMATION

ELEMENT: Man, Input, Sensory, Visual												
FILE NO: 4105-01												
DEFINITION FUNCTION	OBJECT	PARA-METER	PROPERTY	CHARACTERISTIC	CONVERT TO	METHOD	METHOD SUB-DETAIL NO.1	METHOD SUB-DETAIL NO.2	MECHANISM	OPERATION SUB-DETAIL NO.1	OPERATION SUB-DETAIL NO.2	CHANGE WHEN TOLERABLE LIMITS ARE EXCEEDED
ASPECT: Transmit action signal	action signal, electric pulse in optic nerve				electric pulse in lateral geniculate bodies					Spacial displacement of electric pulse		

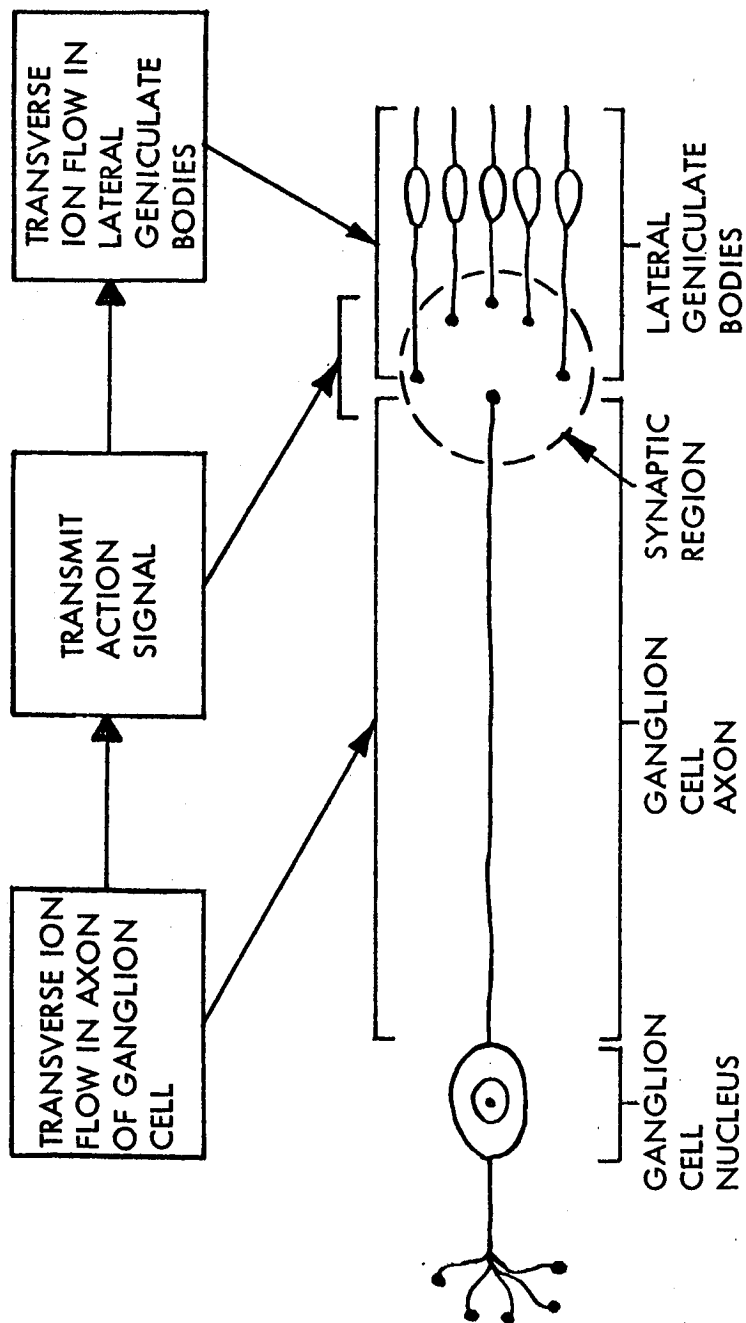
TSC1642

## CONFIGURATION INFORMATION

[illegible]

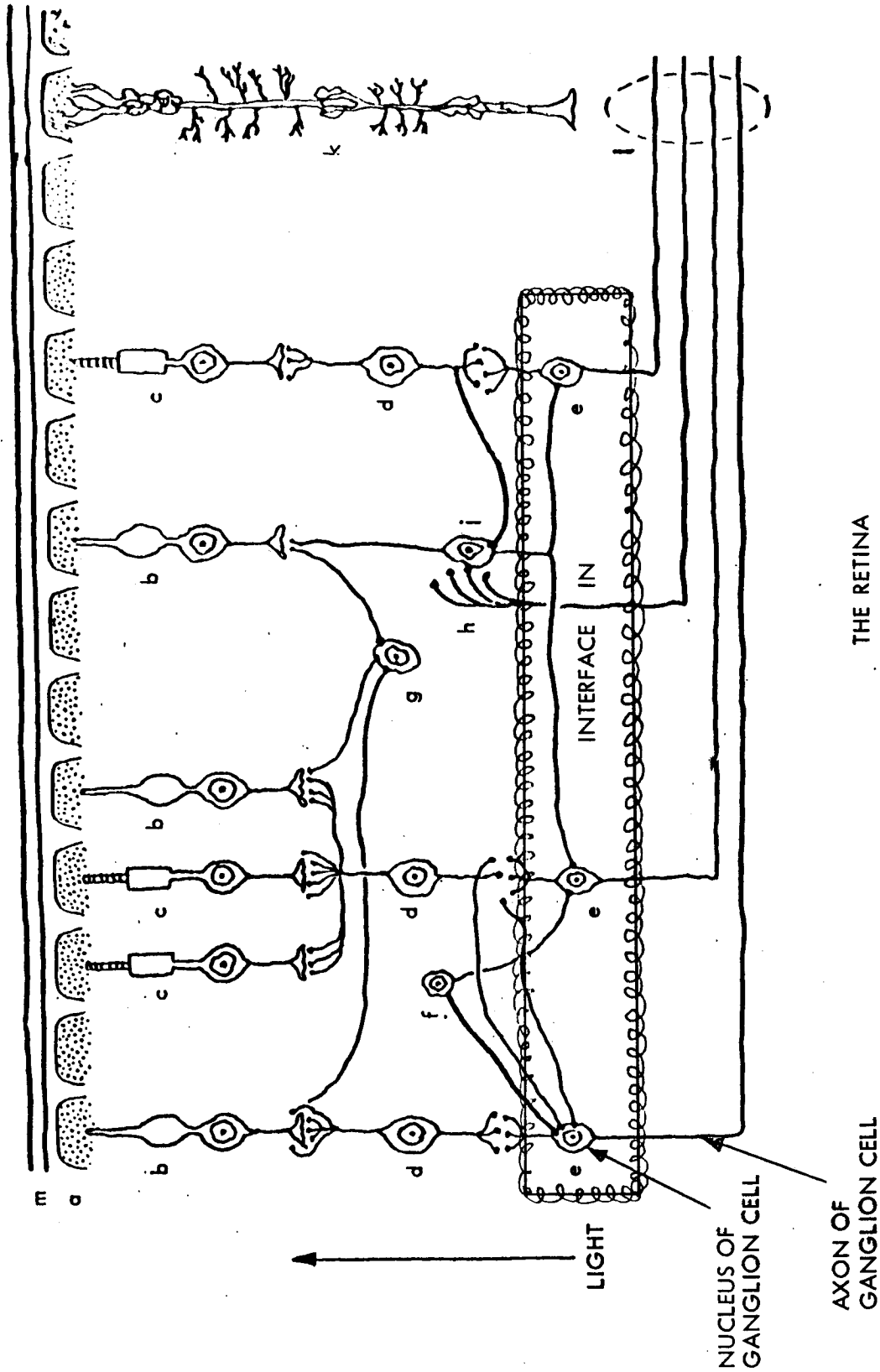
TSC 164:

DRAWING NO: 4-105-01-1



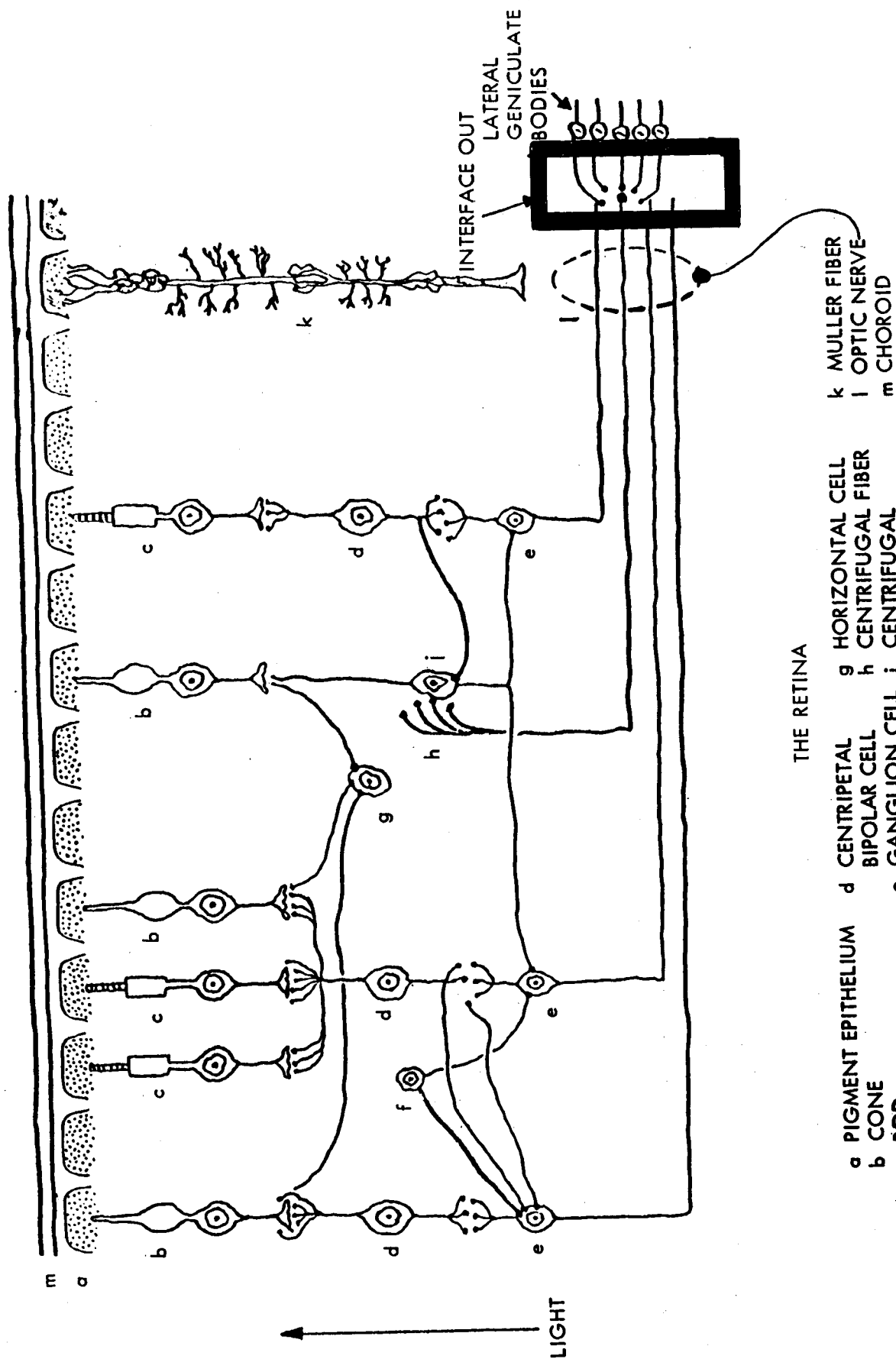
TRANSMIT ACTION SIGNAL FUNCTIONAL SCHEMATIC  
TRANSVERSE SECTION OF GANGLION CELL AND LATERAL  
GENICULATE BODIES  
CONFIGURATION - CONNECTION OF PARTS

DRAWING NO: 4-105-01-1 TSC 2545



- |   |                    |   |                          |   |                           |   |              |
|---|--------------------|---|--------------------------|---|---------------------------|---|--------------|
| a | PIGMENT EPITHELIUM | d | CENTRIPETAL BIPOLAR CELL | g | HORIZONTAL CELL           | k | MULLER FIBER |
| b | CONES              | e | CENTRIFUGAL BIPOLAR CELL | h | CENTRIFUGAL GANGLION CELL | l | OPTIC NERVE  |
| c | RODS               | f | AMACRINE CELL            | i | CENTRIFUGAL BIPOLAR CELL  | m | CHORD        |

CONFIGURATION-INTERFACE IN  
TRANSMIT ACTION SIGNAL FUNCTIONAL ASPECT  
DRAWING NO. 4-105-01-2



# MATERIAL INFORMATION

ELEMENT: Man, Input, Sensory, Visual

FILE NO:

4-105-01

MATERIALS  
(next level)

MATERIALS

TYPE:

optic nerve

lateral

geniculate bodies

REMARKS:

RELATIVE  
COST

PRODUCIBILITY

AVAILABILITY

EXISTENCE

File No: 4-111-01

This is the first file under the influencing factor of configuration. File 4-111-01 is for the aspect called parts. On the Configuration Information sheet the column headed Aspect calls out parts. The sheet is a listing of drawings and does not present data.

Two drawings, No. 4-111-01-1 and -2, are called out in the column Arrangement of Parts. These two drawings also show the Connection of Parts. The drawings present an anatomical view of the eye. Next Drawings 4-111-01-3 and -4 give the dimensions of the eyeball and the retina respectively. Drawing 4-111-01-4 indicates that the retina covers an area of  $266 \text{ mm}^2$ . The retina roughly covers five-sixths of a sphere which is one inch in diameter.

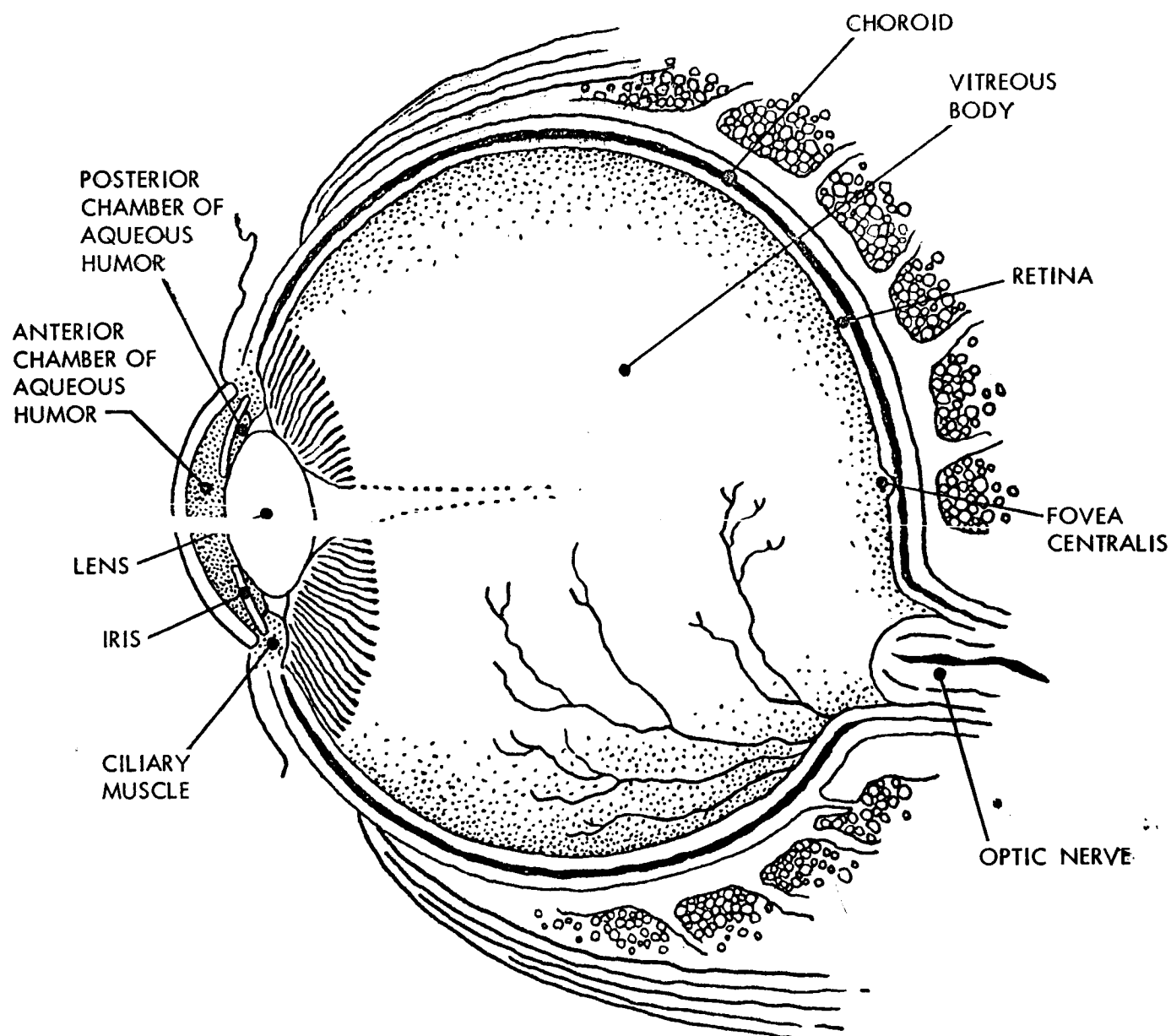
On Drawing 4-111-01-5, the Interface In is shown. The figure indicates that the cornea is the part of the eye that first receives visible radiation. In viewing the Interface Out, Drawing 4-111-01-6, it is seen that the optic nerve and lateral geniculate bodies form the boundary. This is the boundary where the action signal leaves the eye and enters the nervous subsystem.

The Material Information sheet lists the parts of the eye.

SUBSYSTEM FUNCTION			MAN																MACHINE												
			INPUT								DIST. AND CONTROL				OUTPUT				INPUT				DIST. AND CONTROL				OUTPUT				
			SENSORY																SENSORS												
			VISUAL	AUDITORY	GUSTATORY	OLFACTORY	TACTILE	RESPIRATORY	UPPER G.I. TRACT	RADIATION	CARDIOVASCULAR	ENDOCRINE	NERVOUS	SMALL INTESTINE	MUSCULO SKELETAL	SKIN	EXCRETORY	REPRODUCTIVE	RADIATION	MAGNETIC	ELECTRO-STATIC	FORCE	CHEMICAL	POWER	POWER CIRCUITS	CONTROL CIRCUITS	INFORMATION HANDLING	HEAD AND WASTE DISPOSITION	ACTUATORS	DISPLAYS	RADIATION
			01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29
INPUT	DATA	DETECT	79																												
		QUANTIZE	80																												
		QUALIFY	81																												
		TRANSDUCE	82																												
		DISCARD NOISE	83																												
	POWER	TRANSMIT INFO. SIGNAL	84																												
		ACQUIRE	85																												
		QUANTIZE	86																												
		QUALIFY	87																												
		CONVERT	88																												
DISTRIBUTION AND CONTROL	DATA	DISCARD WASTE	89																												
		ACCEPT INFO. SIGNAL	90																												
		ACCEPT INT. CONTROL SIGNAL	91																												
		CONVERT INFO. SIGNAL	92																												
		CORR. CONV. SIG. TO STORE	93																												
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		TRANSMIT DEC. SIGNAL	95																												
		ACQUIRE EXT. POWER	96																												
		ACCEPT INT. POWER	97																												
		CONVERT POWER TO STORE	98																												
OUTPUT	CORRELATE STORED POWER	99																													
	CONV. STORED POWER TO INPUT	100																													
	DISCARD WASTE	101																													
	ACCEPT DEC. SIGNAL	102																													
	CONVERT TO ACTION	103																													
TASKS	CORR. WITH STORE	104																													
	TRANSMIT ACTION SIG.	105																													
	RETRIEVE STORED POWER	106																													
	CONV. TO ACTION	107																													
	CORR. WITH STORE	108																													
SUBSYSTEM	TRANSMIT ACTION	109																													
	SUBSYSTEM		110																												
	PARTS	111																													
	SUPPORT STRUCTURE	112																													
	CONTAINER	113																													
SUBSYSTEM	INTERNAL DYNAMICS	114																													
	EXTERNAL DYNAMICS	115																													
	SUBSYSTEM		116																												
	ACCELERATABLE MASSES	117																													
	CONSTRAINED MASSES	118																													
SUBSYSTEM	CHEMICAL CELLS	119																													
	RADIATION SOURCES	120																													
	PERMANENT MAGNETS	121																													
	ELECTRETS	122																													
	CONDUCTING LOOPS	123																													
SUBSYSTEM	CONDUCTING SURFACES	124																													
	NON-CONDUCTORS	125																													
	SUBSYSTEM		126																												
	TASKS		127																												
			128																												

## CONFIGURATION INFORMATION

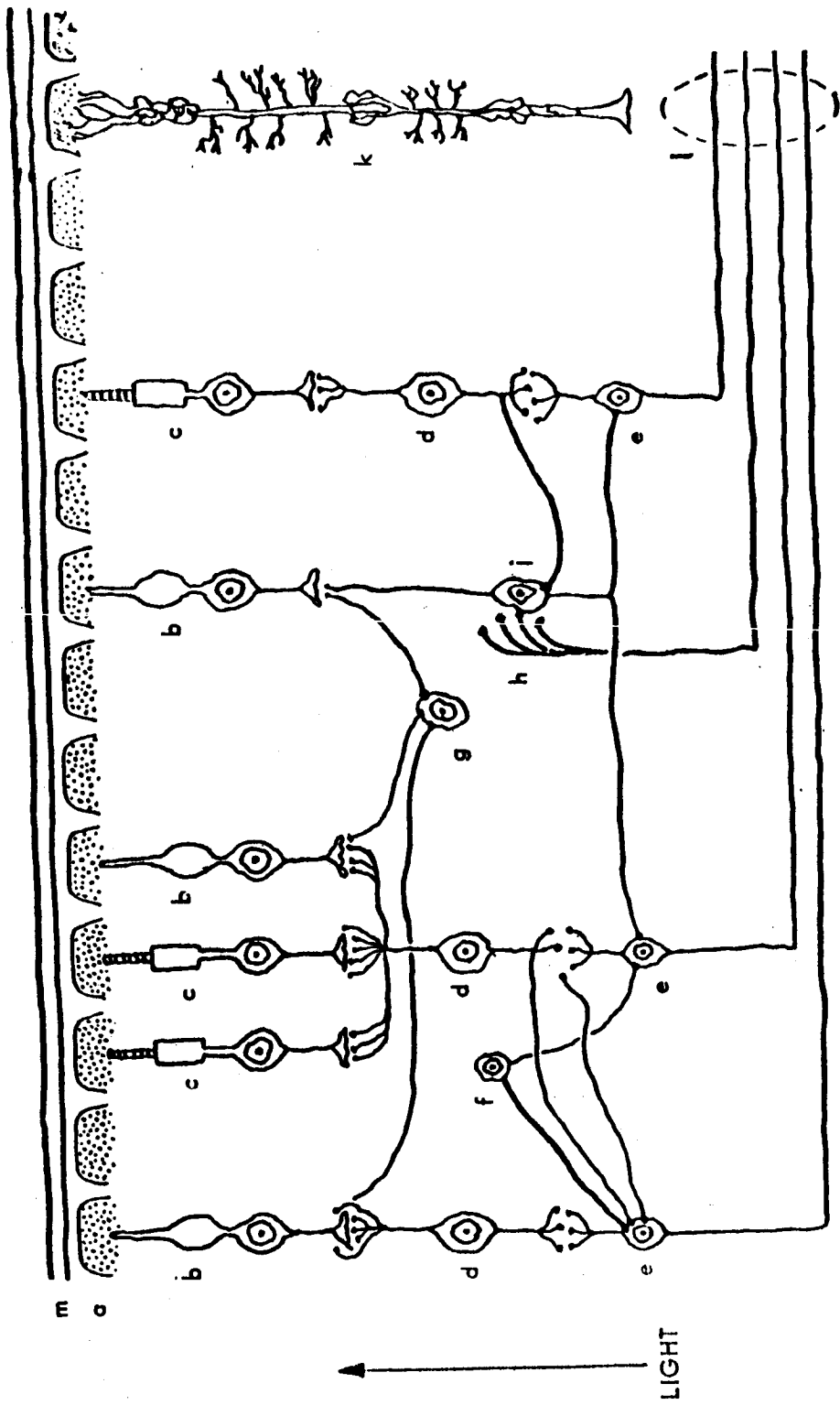
[illegible]



(SOURCE, ATLAS OF HUMAN BODY, FIFTH EDITION, BARNES AND NOBLE, P - 138, 1959)

ARRANGEMENT OF PARTS OF THE EYE  
PARTS CONFIGURATIONAL ASPECT  
DRAWING NO. 4-111-01-1

TSC2218L

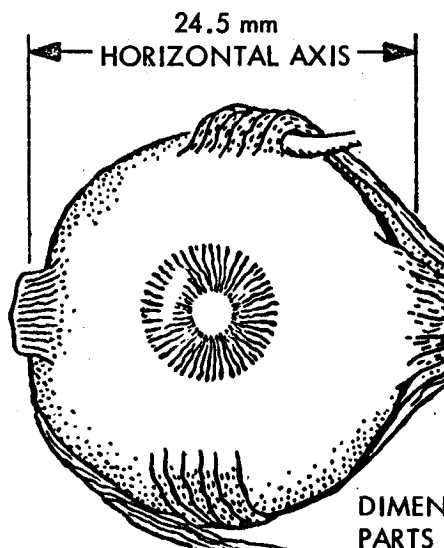
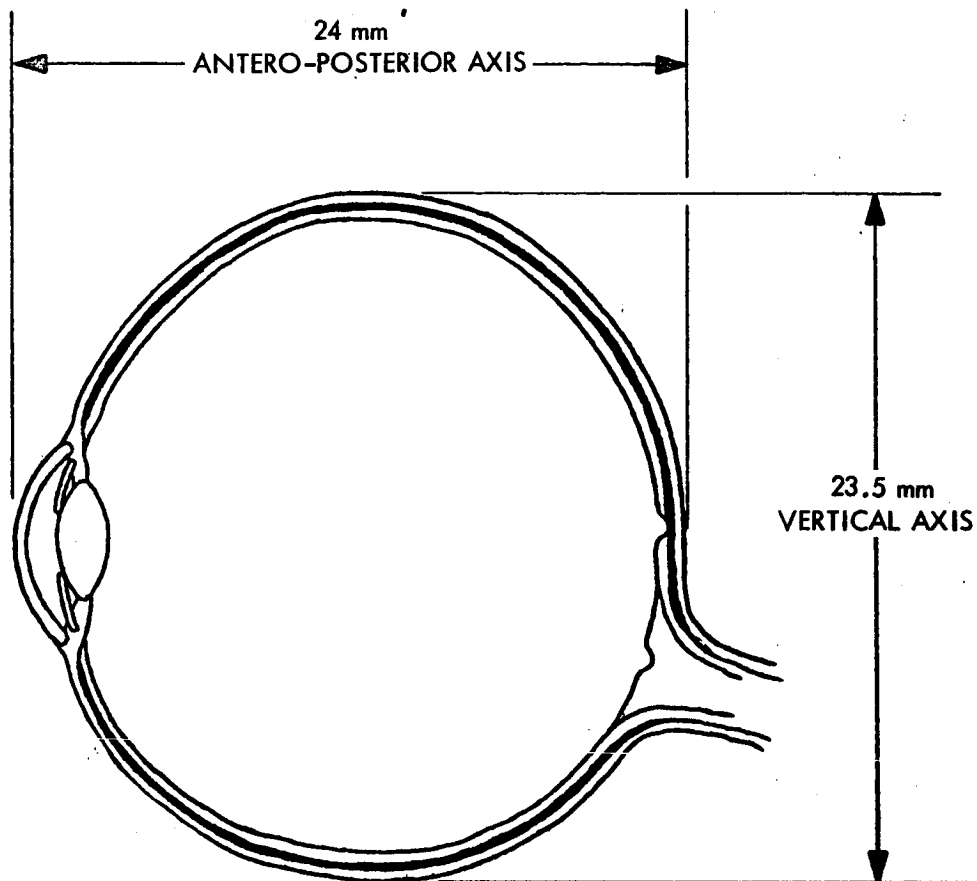


THE RETINA

- a PIGMENT EPITHELIUM
- b CONE
- c ROD
- d CENTRIPETAL BIPOLAR CELL
- e GANGLION CELL
- f AMACRINE CELL
- g HORIZONTAL CELL
- h CENTRIFUGAL BIPOLAR CELL
- i CENTRIFUGAL BIPOLAR CELL
- k MULLER FIBER
- l OPTIC NERVE
- m CHOROID

ARRANGEMENT OF PARTS OF EYE  
PARTS CONFIGURATIONAL ASPECT

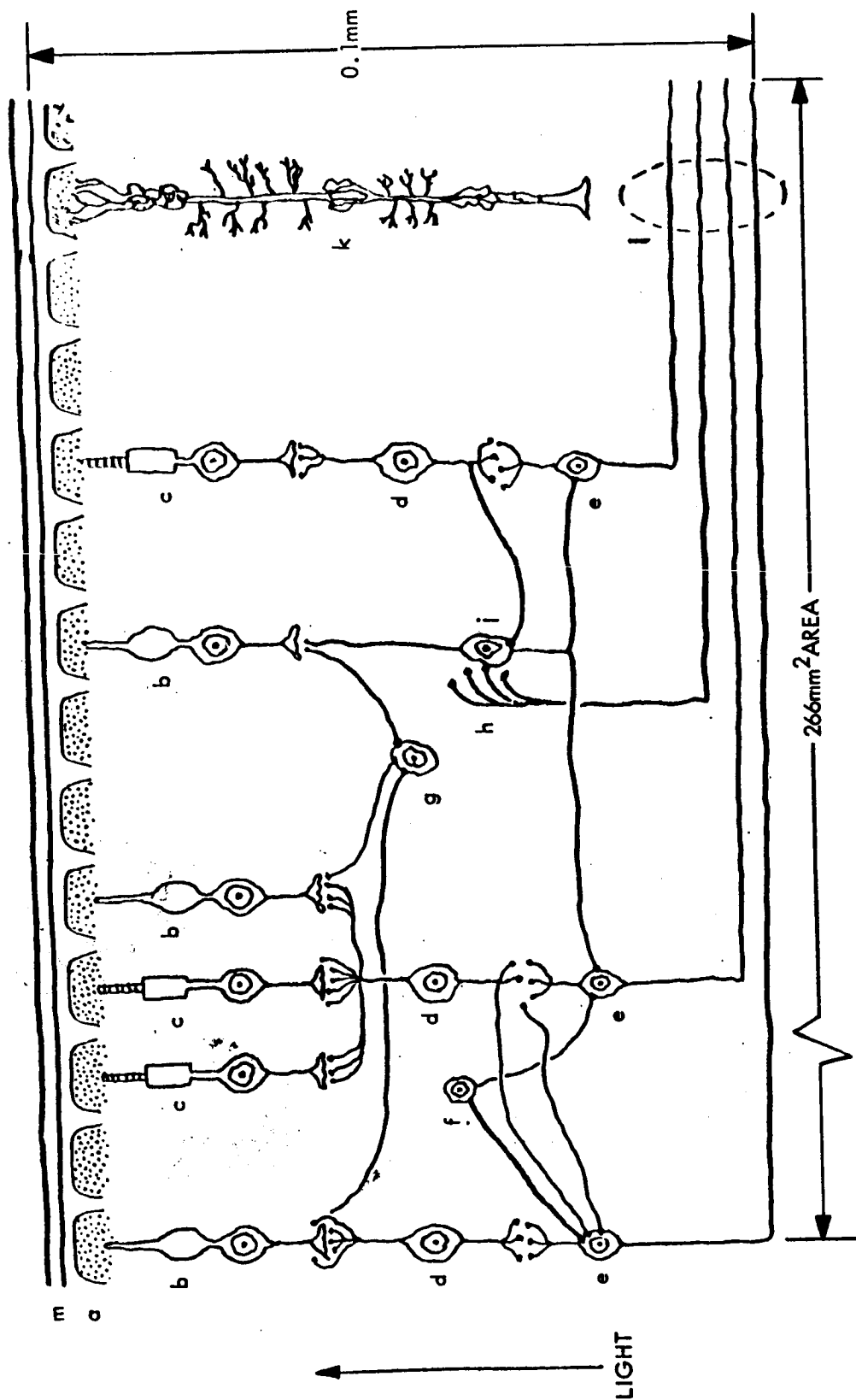
DRAWING NO. 4-1111-01-2



(SOURCE, J.D.SPOONER, OCLULAR ANATOMY, p.11-1957)

DIMENSIONS OF EYE  
PARTS CONFIGURATION ASPECT  
DRAWING NO: 4-111-01-3

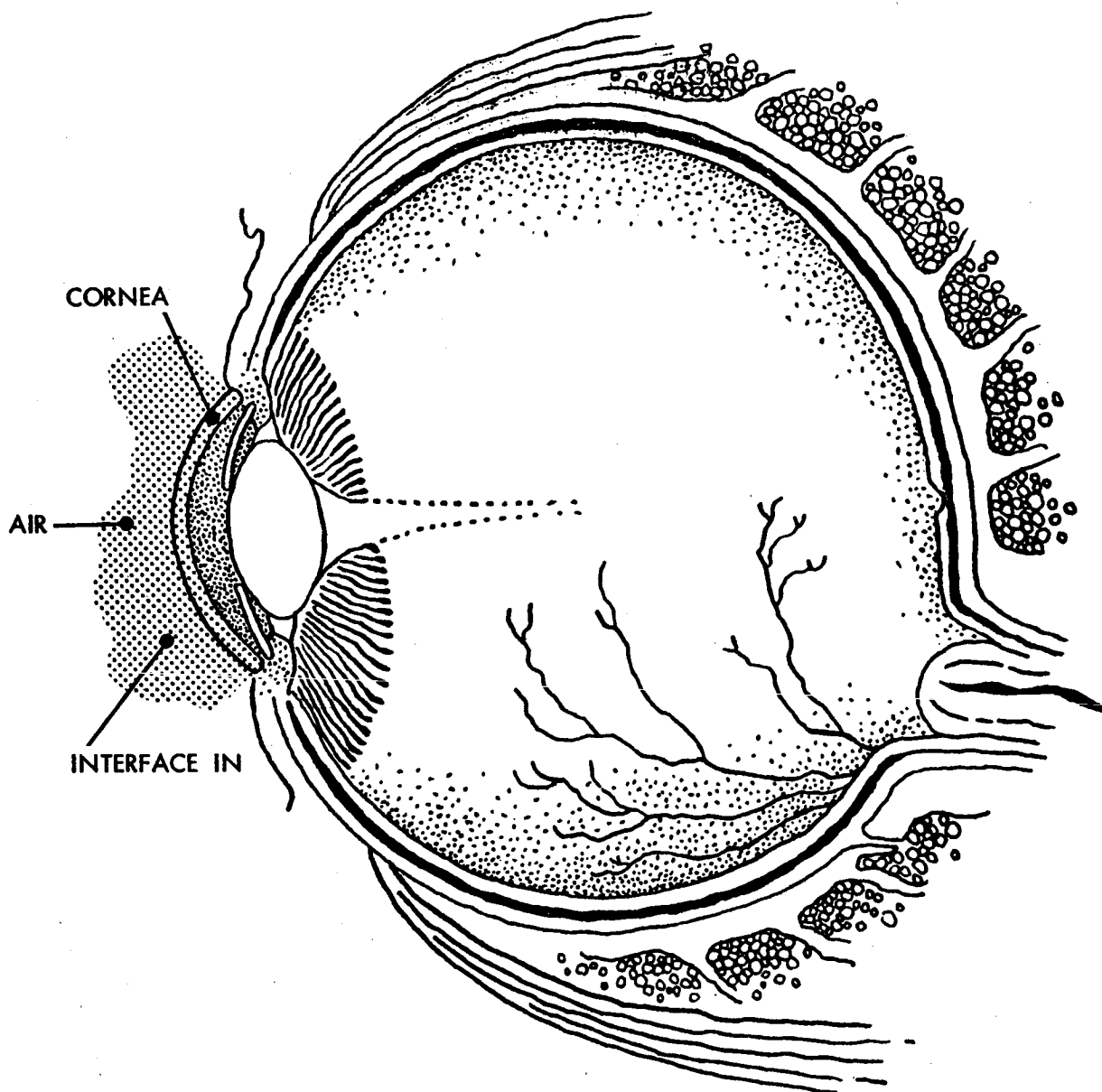
TSC 2382A



THE RETINA

- a. PIGMENT EPITHELIUM
- b. CONE
- c. ROD
- d. CENTRIPETAL BIPOLAR CELL
- e. GANGLION CELL
- f. AMACRINE CELL
- g. HORIZONTAL CELL
- h. CENTRIFUGAL BIPOLAR CELL
- i. CENTRIFUGAL BIPOLAR CELL
- j. CENTRIFUGAL BIPOLAR CELL
- k. MULLER FIBER
- l. OPTIC NERVE
- m. CHOROID

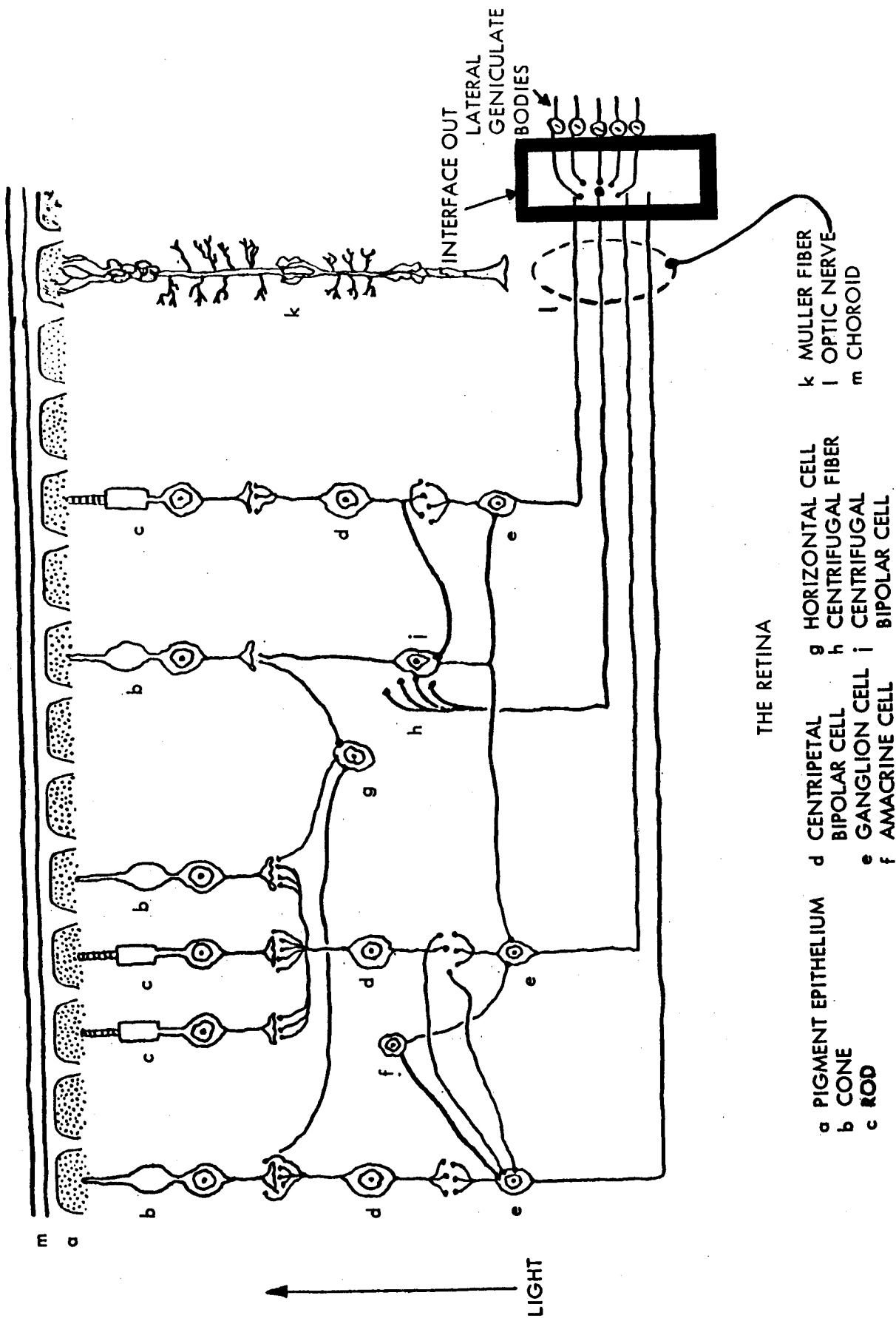
DIMENSIONS OF EYE  
PARTS CONFIGURATIONAL ASPECT



(SOURCE, ATLAS OF HUMAN ANATOMY, FIFTH EDITION, BARNES AND NOBLE, P.138-1959)

INTERFACE IN  
PARTS CONFIGURATIONAL ASPECT  
DRAWING NO.4-111-01-5

TSC2218K



# THE RETINA

- a PIGMENT EPITHELIUM
- b CONE
- c ROD
- d CENTRIPETAL BIPOLAR CELL
- e GANGLION CELL
- f AMACRINE CELL
- g HORIZONTAL CELL
- h CENTRIFUGAL FIBER
- i CENTRIFUGAL BIPOLAR CELL

INTERFACE OUT  
PARTS CONFIGURATIONAL ASPECT

DRAWING NO. 4-111-01-6

# MATERIAL INFORMATION

ELEMENT: Man, Input, Sensory, Visual

FILE NO:

4-111-01

MATERIALS  
(next level)

MATERIALS

TYPE:

cornea

aqueous humor

iris

lens

ciliary muscle

vitreous body

choroid

retina

optic nerve

sclera

sphincter muscle

dilator muscle

REMARKS:

RELATIVE  
COST

PRODUCIBILITY

AVAILABILITY

EXISTENCE

File No. : 4-112-01

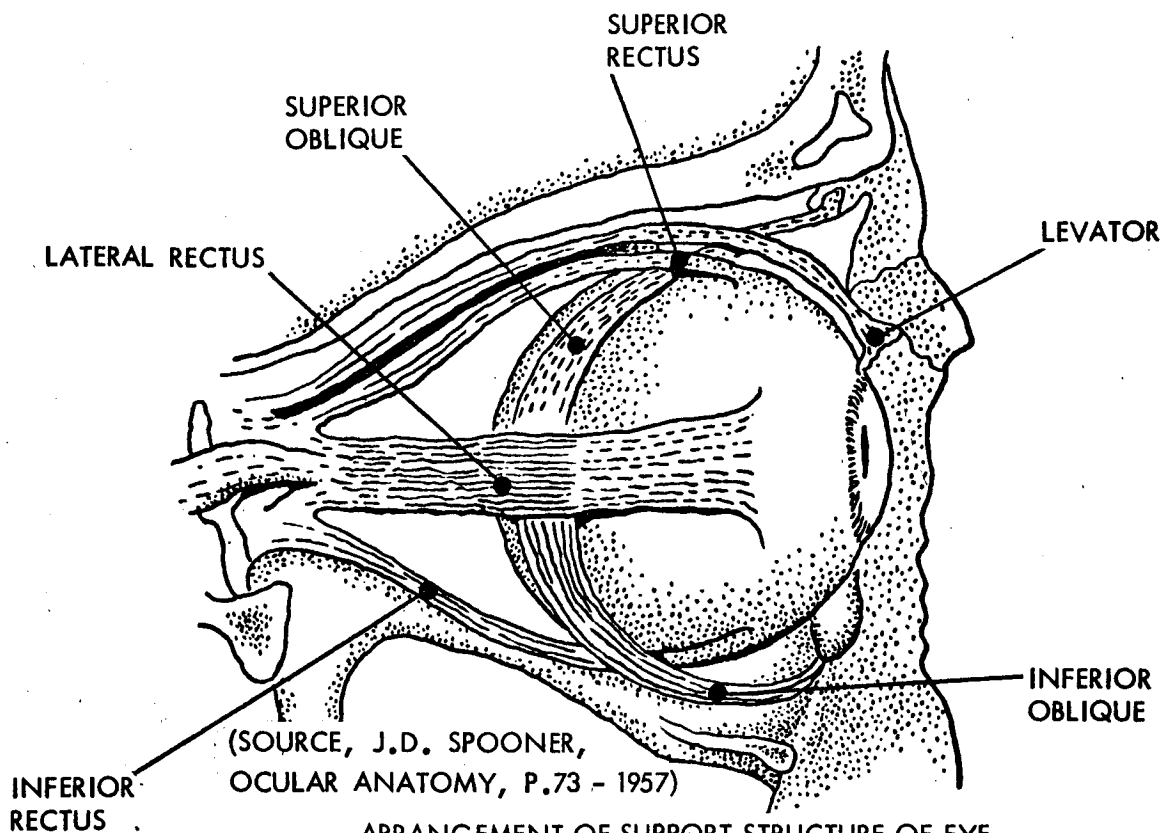
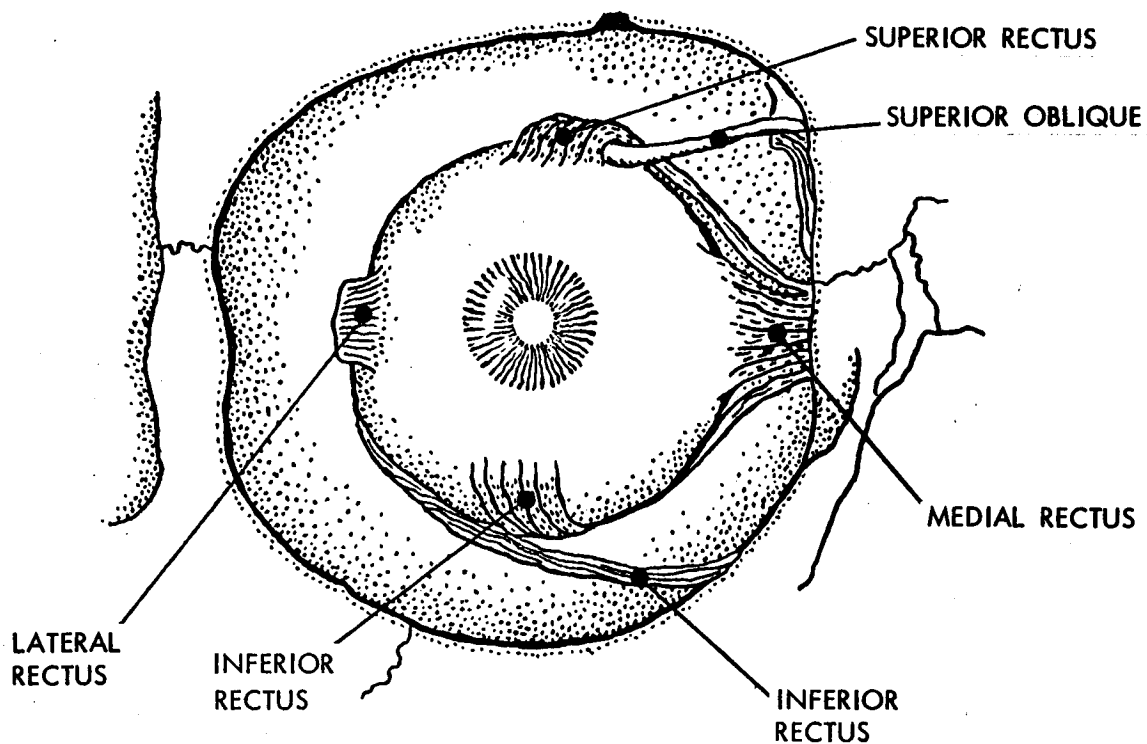
This file contains drawings of the support structure of the eye. On the Configuration Information sheet, two drawings are called out. The first, Drawing 4-112-01-1, is an anatomical illustration that shows the six muscles that move the eyeball as well as the levator muscle that controls the eyelid. The second drawing, No. 4-112-01-2, indicates the direction in which the muscles can rotate the eyeball.

The seven muscles of the support structure are listed on Material Information sheet.



## CONFIGURATION INFORMATION

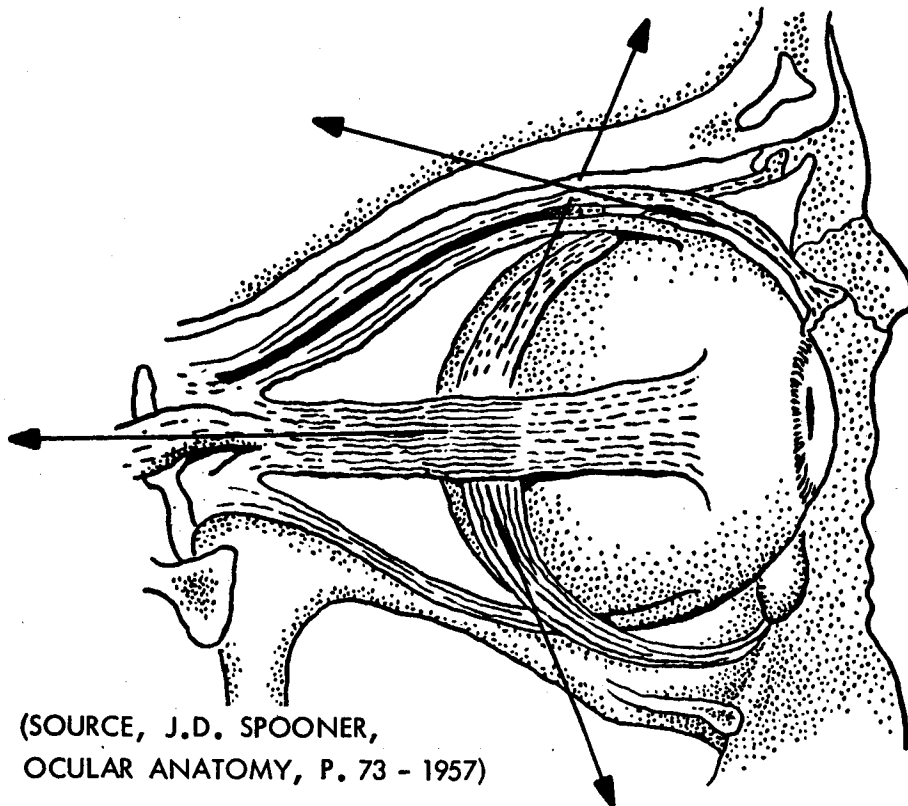
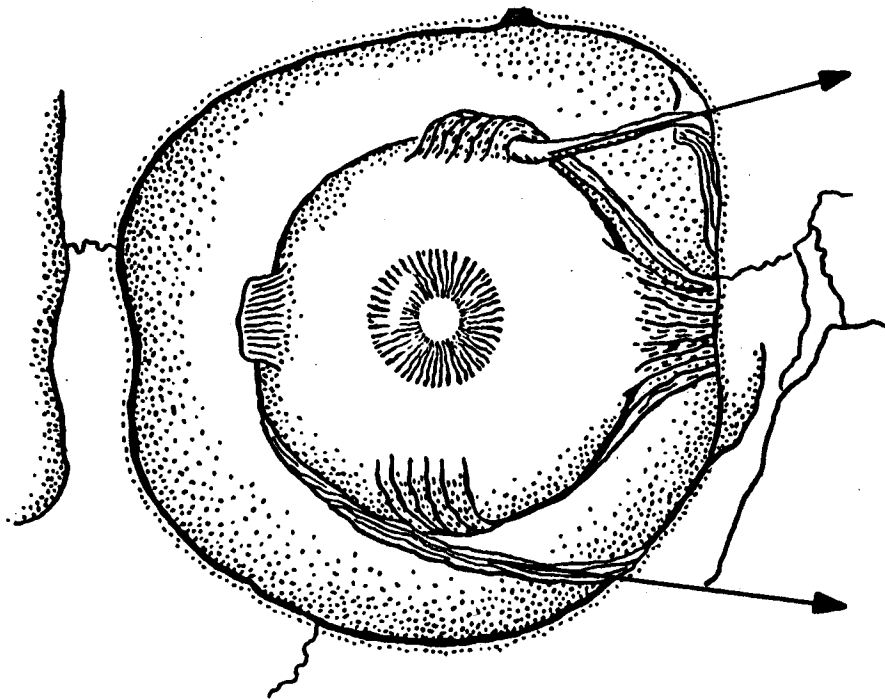
[illegible]



(SOURCE, J.D. SPOONER,  
OCULAR ANATOMY, P.73 - 1957)

ARRANGEMENT OF SUPPORT STRUCTURE OF EYE  
SUPPORT STRUCTURE CONFIGURATIONAL ASPECT  
DRAWING NO.: 4-112-01-1

TSC 2220C



(SOURCE, J.D. SPOONER,  
OCULAR ANATOMY, P. 73 - 1957)

MOTION OF SUPPORT STRUCTURE OF EYE  
SUPPORT STRUCTURE CONFIGURATIONAL ASPECT  
DRAWING NO. 4-112-01-2

TSC 2220B

## MATERIAL INFORMATION

[illegible]

File No: 4-113-01

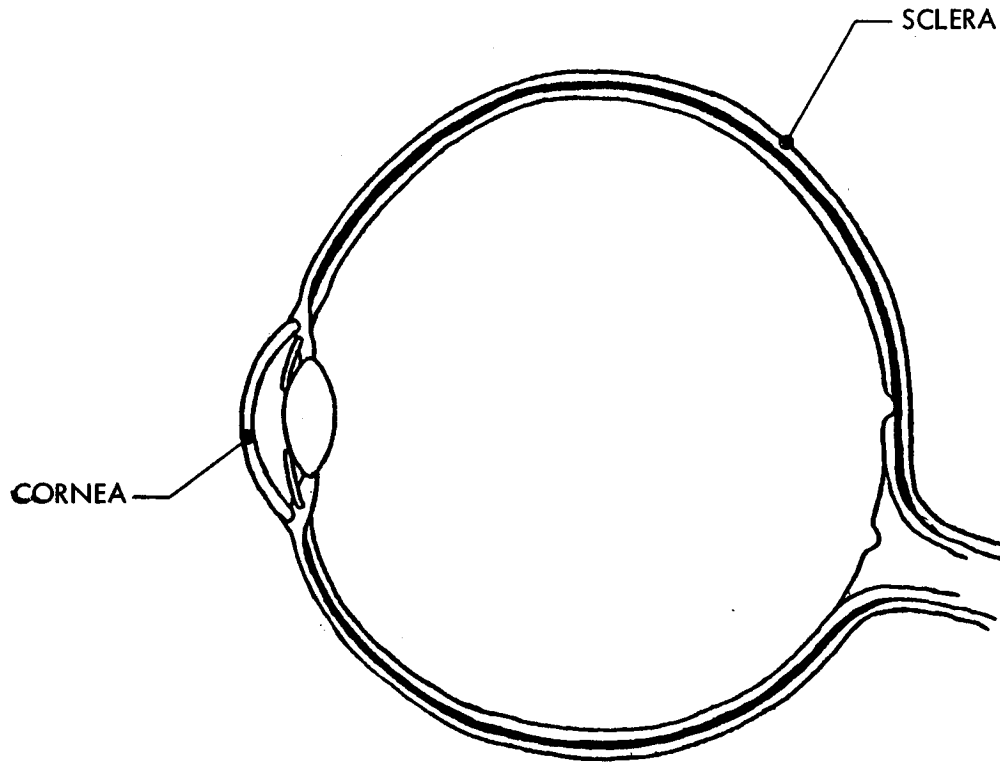
File 4-113-01 covers the configurational aspect called container. The Configuration Information sheet lists drawings of the container of the eye. As is shown on Drawing 4-113-01-1, the cornea and sclera compose the container. The dimensions of the container are given on Drawing 4-113-01-2. These dimensions indicate that the container (eyeball) is nearly round and almost fills a one-inch sphere.

Only the cornea and sclera are listed on the Material Information sheet.

[illegible]

## CONFIGURATION INFORMATION

[illegible]

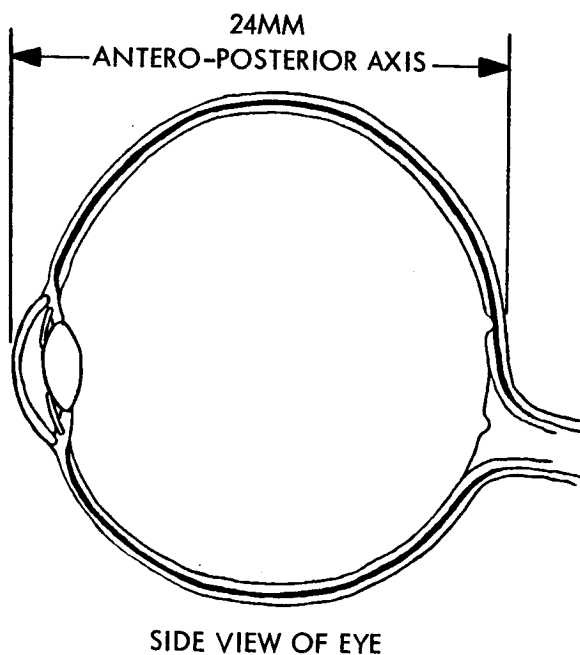
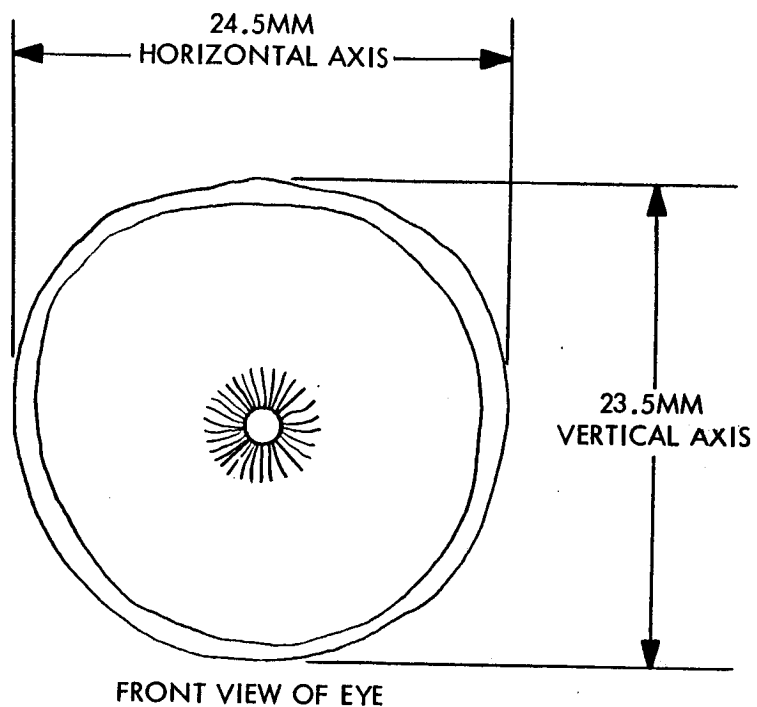


(FROM: ATLAS OF HUMAN ANATOMY,  
FIFTH EDITION, BARNES AND NOBLE,  
1959, P. 138)

ARRANGEMENT OF PARTS OF CONTAINER  
CONTAINER CONFIGURATIONAL ASPECT  
DRAWING NO.: 4-113-01-1

TSC 2382

DRAWING NO. 4-113-01-2



( Source, J.D. Spooner, Ocular Anatomy, p. 11-1957 )

DIMENSIONS OF CONTAINER OF EYE  
CONTAINER CONFIGURATIONAL ASPECT

DRAWING NO. 4-113-01-2

TSC 2220A

# MATERIAL INFORMATION

ELEMENT: Man, Input, Sensory, Visual

FILE NO:

4-113-01

MATERIALS  
(next level)

MATERIALS

TYPE:

sclera

cornea

REMARKS:

RELATIVE  
COST

PRODUCIBILITY

AVAILABILITY

EXISTENCE

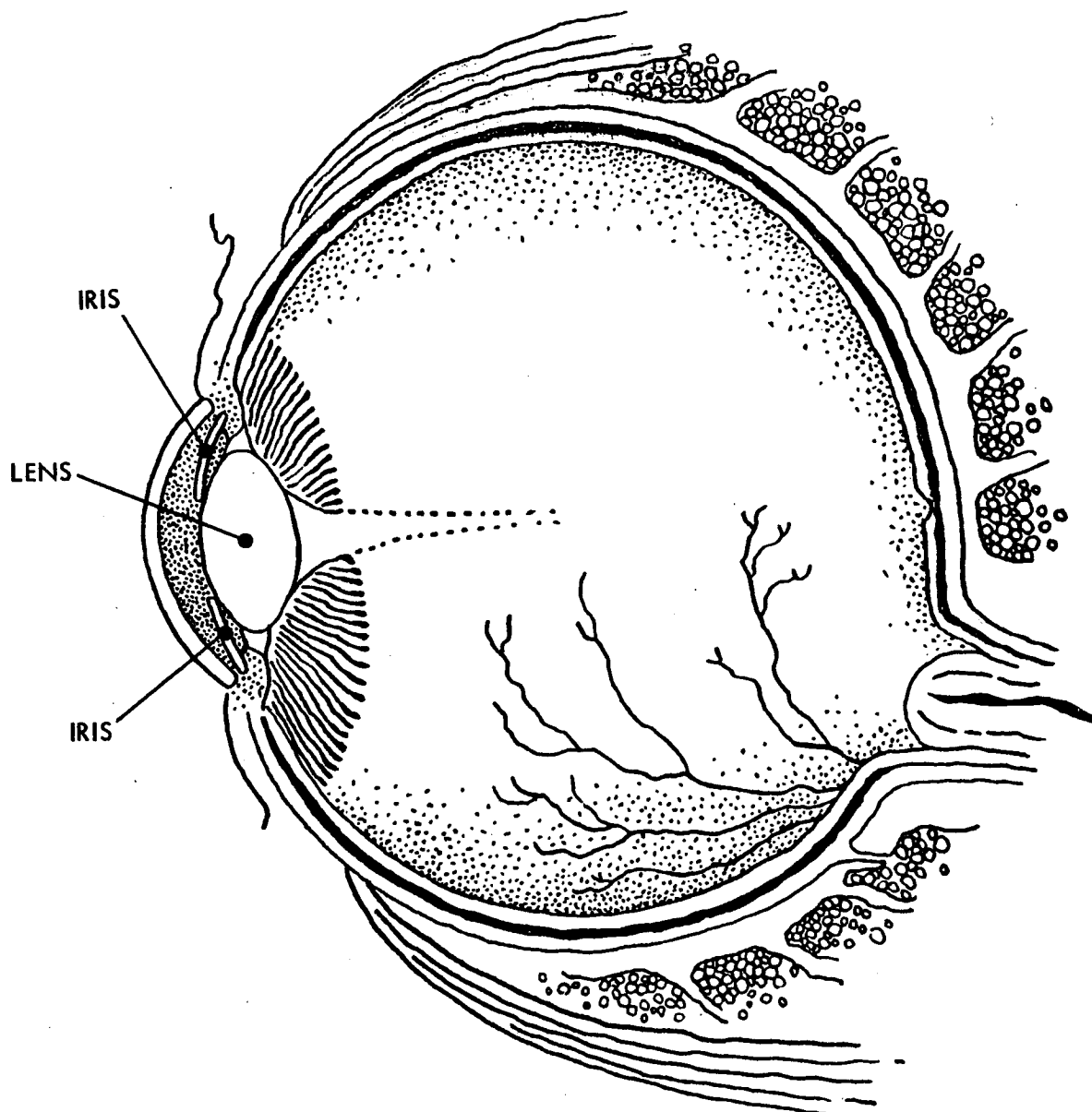
Drawings concerned with the internal dynamics of the eye are included in this file. The Configuration Information sheet lists two drawings. On the first drawing, No. 4-114-01-1, the iris and lens are pointed out because they have motions that take place within the container of the eye. The maximum and minimum limits of these motions are shown on Drawing 4-114-01-2. It may be noted that both the curvature and the diameter of the lens change when accommodation takes place. Accommodation is the change in the eye to bring objects at various distances into focus. The variation in the diameter of the iris to control the amount of light that strikes the retina may also be seen on this drawing.

The iris and lens are listed on the Material Information Sheet as the components that have internal dynamics.

SUBSYSTEM  FUNCTION			MAN																MACHINE												
			INPUT								DIST. AND CONTROL				OUTPUT				INPUT				DIST. AND CONTROL				OUTPUT				
			SENSORY					RESPIRATORY	UPPER G.I. TRACT	RADIATION	CARDIOVASCULAR	ENDOCRINE	NERVOUS	SMALL INTESTINE	MUSCULO SKELETAL	SKIN	EXCRETORY	REPRODUCTIVE	SENSORS				POWER	POWER CIRCUITS	CONTROL CIRCUITS	INFORMATION HANDLING	HEAD AND WAIST DISSIPATION	ACTUATORS	DISPLAYS	RADIATION	
			VISUAL	AUDITORY	GUSTATORY	OLFACTORY	TACTILE												RADIATION	MAGNETIC	ELECTRO-STATIC	FORCE									CHEMICAL
			01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29
INPUT	DATA	DETECT	79																												
		QUANTIZE	80																												
		QUALIFY	81																												
		TRANSDUCE	82																												
		DISCARD NOISE	83																												
	POWER	TRANSMIT INFO. SIGNAL	84																												
		ACQUIRE	85																												
		QUANTIZE	86																												
		QUALIFY	87																												
		CONVERT	88																												
DISTRIBUTION AND CONTROL	DATA	DISCARD WASTE	89																												
		ACCEPT INFO. SIGNAL	90																												
		ACCEPT INT. CONTROL SIGNAL	91																												
		CONVERT INFO. SIGNAL	92																												
		CORR. CONV. SIG. TO STORE	93																												
	POWER	CONV. STORED SIG. TO DEC.	94																												
		TRANSMIT DEC. SIGNAL	95																												
		ACQUIRE EXT. POWER	96																												
		ACCEPT INT. POWER	97																												
		CONVERT POWER TO STORE	98																												
OUTPUT	CORRELATE STORED POWER	99																													
	CONV. STORED POWER TO INPUT	100																													
	DISCARD WASTE	101																													
	ACCEPT DEC. SIGNAL	102																													
	CONVERT TO ACTION	103																													
OUTPUT	POWER	CORR. WITH STORE	104																												
		TRANSMIT ACTION SIG.	105																												
		RETRIEVE STORED POWER	106																												
		CONV. TO ACTION	107																												
		CORR. WITH STORE	108																												
TRANSMIT ACTION	109																														
SUBSYSTEM																															
CONFIGURATION			110																												
		PARTS	111																												
		SUPPORT STRUCTURE	112																												
		CONTAINER	113																												
		INTERNAL DYNAMICS	114																												
		EXTERNAL DYNAMICS	115																												
SUBSYSTEM																															
MATERIALS			116																												
			117																												
			118																												
			119																												
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			121																												
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			125																												
SUBSYSTEM																															
TASKS			126																												
			127																												
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			131																												
			132																												
			133																												
			134																												
			135																												
			136																												

## CONFIGURATION INFORMATION

[illegible]

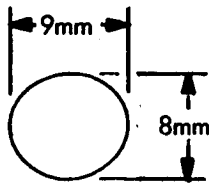


(SOURCE, ATLAS OF HUMAN BODY, FIFTH EDITION, BARNES AND NOBLE, P:138 - 1959)

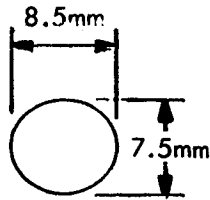
ARRANGEMENT OF PARTS  
INTERNAL DYNAMICS CONFIGURATIONAL ASPECT  
DRAWING NO. 4-114-01-1

TSC2218J

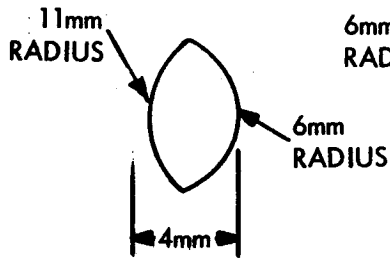
DRAWING NO: 4-114-01-2



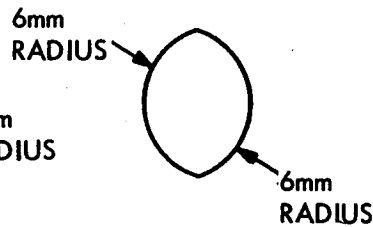
FRONT  
VIEW



FRONT  
VIEW



CROSS-SECTION

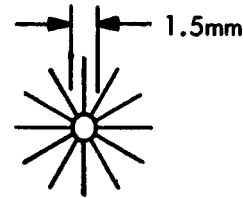


CROSS-SECTION

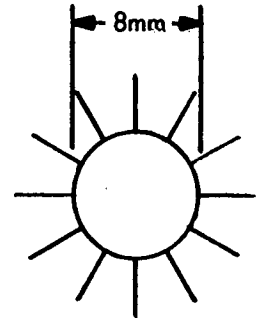
LENS  
UNACCOMMODATED

(SOURCE, J.D. SPOONER, OCULAR ANATOMY,  
p. 11-1957)

LENS  
FULL  
ACCOMMODATION



IRIS  
MAXIMUM  
CONSTRICTION



IRIS  
MAXIMUM  
DILATION

(SOURCE, F.H. ADLER, PHYSIOLOGY OF  
THE EYE, p. 170-1959)

MOTION  
PARTS CONFIGURATIONAL ASPECT

DRAWING NO: 4-114-01-2 TSC 2544

[illegible]

TSC 1643

File No: 4-115-01

File 4-115-01 covers the configuration aspect called external dynamics. The Configuration Information sheet calls out Drawing 4-115-01-1. This drawing indicates that the conjunctiva has dynamics that are external to the container of the eye. The conjunctiva is controlled by the levator muscle (Drawing 4-112-01-1). On Drawing 4-115-01-1, the motion of the conjunctiva is shown.

On the Material Information sheet, the conjunctiva is listed.

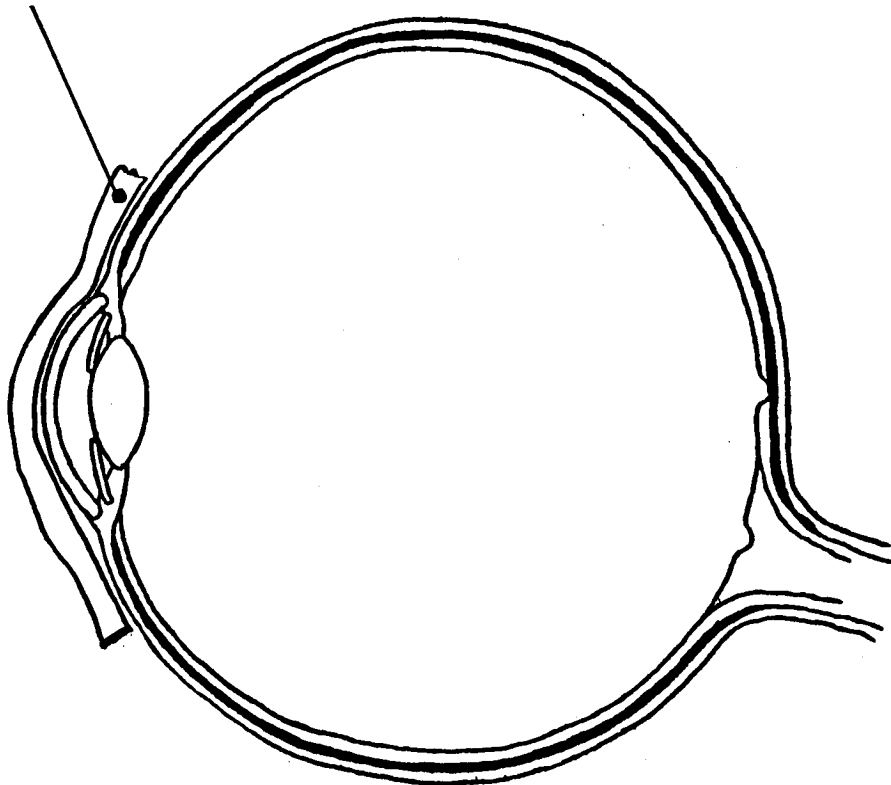
[illegible]

## CONFIGURATION INFORMATION

[illegible]

DRAWING NO.4-115-01-1

CONJUNCTIVA



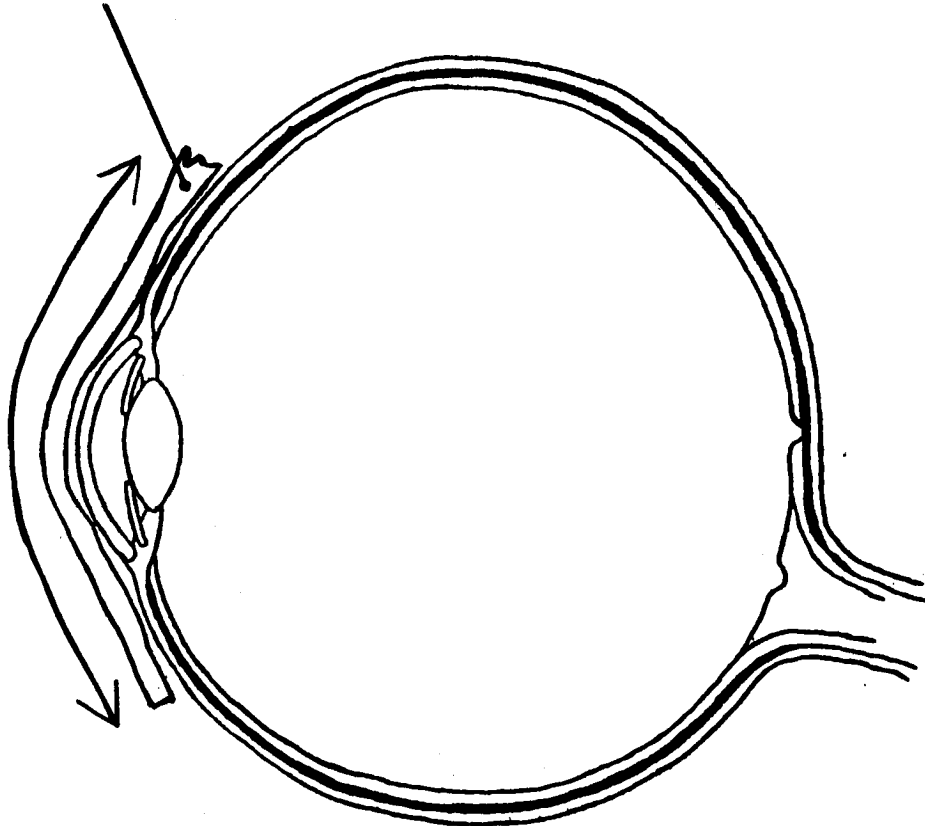
(SOURCE, ATLAS OF HUMAN BODY, FIFTH EDITION, BARNES AND NOBLE, P.138 - 1959)

ARRANGEMENT OF PARTS  
TRANSVERSE SECTION OF EYE  
EXTERNAL DYNAMICS CONFIGURATIONAL ASPECT  
DRAWING NO.4-115-01-1

TSC 2218H

DRAWING NO. 4-115-01-2

CONJUNCTIVA



MOTION  
TRANSVERSE SECTION OF EYE  
EXTERNAL DYNAMICS CONFIGURATIONAL ASPECT  
DRAWING NO. 4-115-01-2

TSC 3347

# MATERIAL INFORMATION

ELEMENT: Man, Input, Sensory, Visual

FILE NO:

4-115-01

MATERIALS  
(next level)

MATERIALS

TYPE:

Conjunctiva

REMARKS:

RELATIVE  
COST

PRODUCIBILITY

AVAILABILITY

EXISTENCE

File No: 4-116-01

The Material Information sheet contains a list of the major components of the eye. No data is entered in the columns labeled Existence, Availability, Producibility, and Relative Cost, since all of the components are known to occur in every human eye. These columns are needed when designing a component.

[illegible]

# MATERIAL INFORMATION

ELEMENT: Man, Input, Sensory, Visual

FILE NO:

4-116-01

MATERIALS (next level)	EXISTENCE	AVAILABILITY	PRODUCIBILITY	RELATIVE COST	REMARKS:
MATERIALS					
TYPE:					
cornea					
aqueous humor					
iris					
lens					
vitreous body					
choroid					
pigment epithelium					
rod					
cone					
centripetal cell					
ganglion cell					
horizontal cell					
amacrine cell					
centrifugal cell					
centrifugal fiber					
muller fiber					
optic nerve					
sclera					
superior rectus					
inferior rectus					
lateral rectus					
medial rectus					
superior oblique					
inferior oblique					

TSC K43

(continued on next page)

(continued from previous page)

[illegible]

COMPONENT LEVEL EXAMINATION OF  
THE OPERATION OF THE HUMAN EYE

## COMPONENT LEVEL EXAMINATION OF THE OPERATION OF THE HUMAN EYE

The human eye is composed of many types of organic cells. Each of these cells are components of the visual sensor. A complete component level analysis would require that the Methodological procedure followed at the Subsystem Level be repeated for every type of cell within the eye.

As Table I indicates, there are at least 66 types of cellular structures in the eye. The table shows that a number of components may be grouped together to form parts of the eye. For example, there are 13 components that form the cornea. To investigate the components of the eye requires repeated applications of the Methodology.

A comprehensive study of most of these components is not warranted at this time. Knowledge of the processes conducted within a few components could however give insight into a considerable segment of the visual mechanism. This may be illustrated by examining the basic visual functions of a number of parts of the eye. Examples of visual functions are indicated in the following list: cornea-frequency and intensity filtering and refraction of light; lens - refraction of light and iris - control of amount of light entering eye. There are many other parts of the eye that have visual functions that are well known, but there are components that perform a large and complex portion of the visual process and are not presently well understood. These are the components that deserve study.

<u>Cornea</u>		<u>Retina</u>	
1.	Basal cells	35.	Pigment epithelium
2.	Polyhedral cells	36.	Rod cells
3.	Epithelial cells	37.	Cone cells
4.	Endothelial cells	38.	Centripetal cells
5.	Corneal corpuscles (fixed cells)	39.	Ganglion cells
6.	Leucocytes (wandering cells)	40.	Horizontal cells
7.	Lymph cells	41.	Amacrine cells
8.	Nerve cells (neurons)	42.	Centrifugal cells
9.	Vascular loops (blood vessels)	43.	Centrifugal fibers
10.	Bowman's membrane	44.	Muller fibers
11.	Descemet's membrane	45.	<u>Optic Nerve</u>
12.	Elastic fibers	46.	<u>Aqueous Humor</u>
13.	Inelastic fibers (collagenous fibers)	47.	<u>Vitreous Body</u>
<u>Iris</u>		<u>Sclera</u>	
14.	Epithelial cells	48.	Inelastic fibers (collagenous fibers)
15.	Endothelial cells	49.	Elastic fibers
16.	Pigment cells	50.	Fixed cells
17.	Vascular loops	51.	Pigment cells
18.	Inelastic fibers	52.	Nerve cells
19.	Elastic fibers	53.	Vascular loops
20.	Dilator muscle	54.	<u>Conjunctiva</u>
21.	Sphincter muscle	55.	Levator muscle
<u>Lens</u>		<u>Muscles</u>	
22.	Epithelial cells	56.	Superior rectus
23.	Lens fibers	57.	Inferior rectus
24.	Cement substance	58.	Lateral rectus
25.	Suspensory fibers	59.	Medial rectus
<u>Ciliary Muscle</u>		60.	Superior oblique
26.	Muscle fibers	61.	Inferior oblique
27.	Elastic tissue	<u>Choroid</u>	
28.	Nerve cells	62.	Vascular loops
<u>Ciliary Body</u>		63.	Pigment cells
29.	Pigment cells	64.	Hyaloid cells
30.	Epithelial cells	65.	Elastic fibers
31.	Hyaloid cells	66.	Inelastic fibers (collagenous fibers)
32.	Processes		
33.	Vascular loops		
34.	Connective tissue		

## COMPONENTS OF THE HUMAN EYE

Table I

## OUTLINE OF PHOTORECEPTOR PROCESSES

Two components that are involved in the major energy conversion that occurs within the eye are the rod cells and the cone cells (the photoreceptors). There is considerable similarity in the operation of these cells since both absorb visual radiation and convert it into neural pulses that excite the centripetal bipolar cells (primary neurons of the eye). An examination of one of these components will yield a considerable amount of information that will apply to the other. To date much more effort has been expended in studying the rod cells, though it has been found that the chemical cycle traced by both of the photoreceptors is closely related.

Quite naturally subjects other than humans are required to supply rod cells for study. It has been learned that the photochemical substance rhodopsin found in the rods of man is also present in the retinae of mammals, birds, amphibians, and sea vertebrates. The retinae of cattle, frogs, and rats have been used as sources of rhodopsin. Cone cells contain the visual pigment iodopsin that is experimentally secured from chicken retinae.<sup>1</sup>

## Rhodopsin

The photochemical rhodopsin sometimes referred to as visual purple, is concentrated at the rod surface. Visual purple is a complex substance that has not been analyzed completely; however, it can be said that this organic compound contains chromophores and a protein (scotopsin). The number of chromophores per protein molecule is not known, and estimates range from one to ten.<sup>2</sup> A chromophore is that portion of a photochemical that selectively absorbs part of the visible spectrum.<sup>3</sup> In rhodopsin the chromophore is called retinene<sub>1</sub>, which has the formula  $C_{19}H_{27}CHO$ . Iodopsin contains retinene<sub>1</sub> and a protein called photopsin.

Molecules of retinene<sub>1</sub> and protein allow their free electrons to mutually interact to construct single covalent bonds between each adjacent atom as well as to build  $\pi$ -orbitals. These orbitals are formed by the excess electrons that are not part of the covalent bonds and extend over the whole length of the conjugated chain. In the unexcited state the electrons occupy orbitals of the lowest energy; when absorption of light quanta takes place, the electrons enter orbitals of higher energy.<sup>4</sup>

"The oscillating electric vector of light causes the  $\pi$ -electrons to congregate backwards and forwards along the conjugated chain, first at one end and then at the other. When the light is of the proper frequency to correspond with the rhythm of these oscillations, it is strongly absorbed (the fundamental band in the visible)."<sup>5</sup>

The fundamental band defines the wavelength of the absorption maximum (symbolized as  $\lambda$  max.). This parameter is used because the only known way of characterizing a visual pigment is to measure its light absorbing properties.

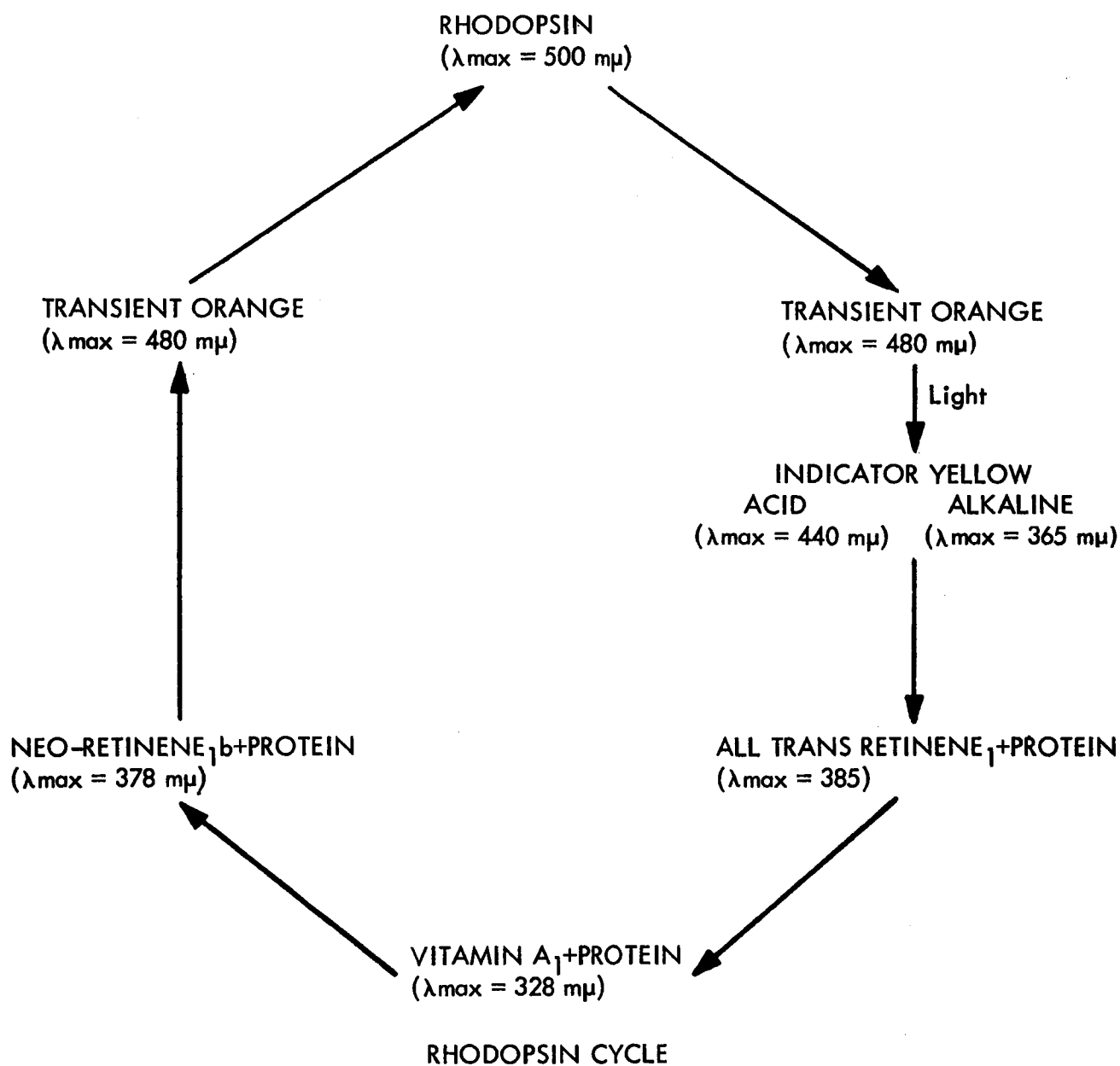
When the chromophore of rhodopsin absorbs a quantum of energy, the rise in electronic levels causes a change in the configuration of the chromophore so that it releases the protein and dissociation takes place. This causes the electric tension between chromophore and protein to disappear.<sup>6</sup>

### Rhodopsin Cycle

Perhaps the best method of explaining the chemical changes that rhodopsin undergoes is to present the complete cycle that this photochemical undergoes and then give the necessary details. Figure I is a diagram of the rhodopsin cycle.

Even before exposure to light, rhodopsin can form transient orange. At room temperature, transient orange has a very short life, and in the presence of light is converted to indicator yellow, which is the first stable decomposition product of rhodopsin. In an acid (pH 5.2) solution, the indicator is bright yellow, while in a base (pH=9-9.5), the chemical is nearly colorless.<sup>7</sup>

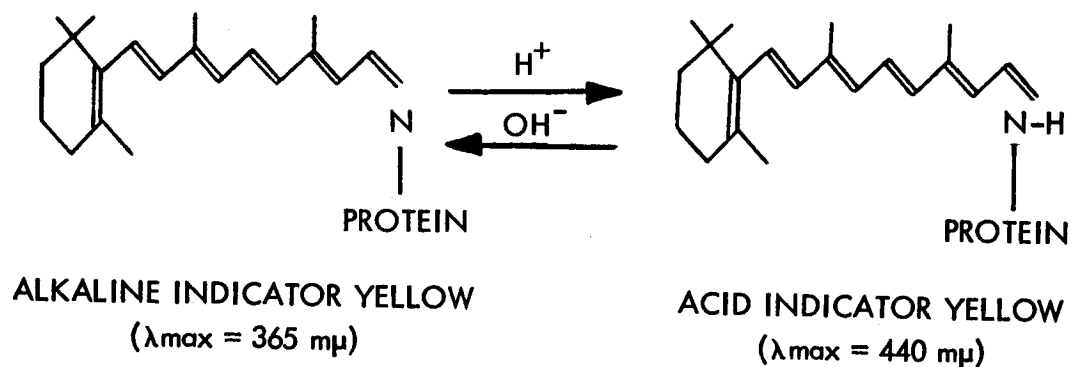
Indicator yellow is composed of the chromophore retinene<sub>1</sub> and a protein. The configuration of indicator yellow is shown in Figure II. If thermal energy is given to indicator yellow, there is decomposition into all trans retinene<sub>1</sub> and protein. All trans retinene<sub>1</sub> is the isomer of the chromophore retinene<sub>1</sub> that involves the least strain. Retinene<sub>1</sub> occurs in two types of isomers, cis and trans. The basic difference between cis and trans isomers is shown in Figure III.



(ADAPTED FROM DARTNALL, THE VISUAL PIGMENTS, 1957,  
PAGE 54 AND 152)

Figure I

TSC 3344

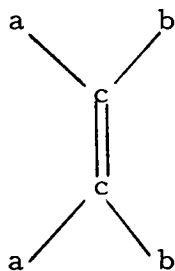


ALKALINE AND ACID FORMS OF INDICATOR YELLOW  
 ( DARTNALL, THE VISUAL PIGMENTS, 1957, PAGE 109 )

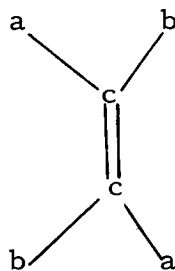
Figure II

TSC 3343

cis isomer



trans isomer



## Isomers of Chromophores

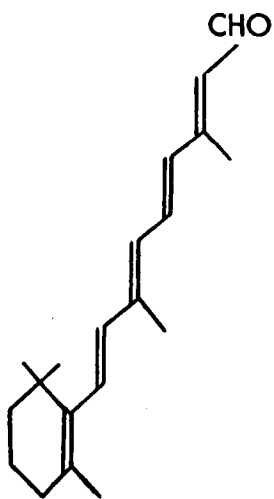
(Dartnall, The Visual Pigments, 1957, Page 127)

Figure III

All trans-retinene<sub>1</sub> has the configuration shown in Figure IV. The cis isomer will be encountered in the discussion of the resynthesis of rhodopsin. By thermal and enzymic action, all trans retinene<sub>1</sub> is converted to vitamin A<sub>1</sub>. The protein molecule is still present and is not bonded to the vitamin A<sub>1</sub>. The shorthand structural formula for vitamin A<sub>1</sub> is shown in Figure V.

Vitamin A<sub>1</sub> is the final chemical formed in the decomposition phase of rhodopsin. This phase of the rhodopsin cycle takes place when light impinges on the photoreceptors. An environment of darkness is required to allow the regeneration of visual purple to take place.

It has been found that the photoreceptors must be in contact with the pigment epithelium to allow rhodopsin to regain its color in darkness, but this contact is not necessary during the bleaching of the photochemical.<sup>8</sup> This observation brings up the question of how the pigment epithelium influences the regeneration process.



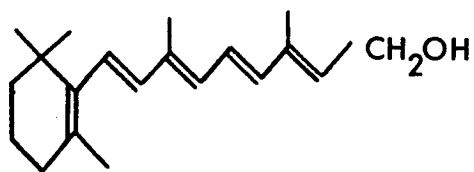
ALL TRANS RETINENE<sub>1</sub>

$C_{19}H_{27}CHO$

( $\lambda_{max} = 385 m\mu$ )

Figure IV

TSC 3340



VITAMIN A<sub>1</sub>

$C_{19}H_{27}CH_2OH$

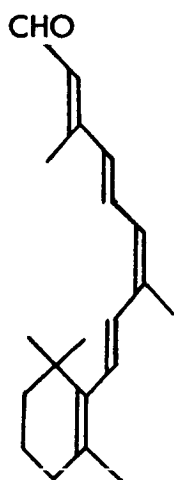
( $\lambda_{max} = 328 m\mu$ )

Figure V

TSC 3341

Microscopic examination has disclosed that the pigment epithelium has processes that project like bristles from a brush and lie in the spaces between the photo-receptors. The processes contain pigment in granular and spindle form.<sup>9</sup> During regeneration the outer segment of the cone photo-receptors has been observed to lie in contact with the processes of the epithelium and to directly absorb pigment granules.<sup>10</sup> These granules very likely take part in the photochemical cycle that is carried out by the cones. Though not yet observed for the rods, a similar exchange of pigment granules probably is carried out by this second type of receptor. To date the importance of this phenomenon in the photochemical cycle has not been explained.

Laboratory tests indicate that regeneration can be started by introducing alcohol dehydrogenase that acts as a catalyst in the oxidation of vitamin A<sub>1</sub> to neo-retinene<sub>1</sub> b, which is a cis isomer of retinene<sub>1</sub>.<sup>11</sup> Figure VI illustrates the configuration of neo-retinene<sub>1</sub> b. A spontaneous energy releasing reaction takes place in which neo-retinene<sub>1</sub> b and protein recombine to form the original photochemical. Thus, the rhodopsin cycle is completed.



THREE CIS NEO-RETINENE<sub>1</sub> b

$C_{19}H_{27}CHO$   
 $(\lambda_{max} = 378 \text{ m}\mu)$

Figure VI

TSC 3342

References for Outline of Photoreceptor Processes

1. Dartnall, H. J. A., The Visual Pigments, John Wiley and Sons, New York, 1957, p. 37.
2. Hartridge, Hamilton, Recent Advances in the Physiology of Vision, The Blakistan Company, Philadelphia, 1950, p. 38.
3. Adler, Francis Feed, Physiology of the Eye, Third Edition, C. V. Mosby Company, St. Louis, 1959, p. 506.
4. Dartnall, p. 101.
5. Dartnall, p. 133.
6. Dartnall, p. 123.
7. Dartnall, p. 52.
8. Dartnall, p. 26
9. Last, R. J., Anatomy of the Eye and Orbit, W. B. Saunders Company, Philadelphia and London, 1961, p. 94.
10. Last, p. 97.
11. Dartnall, 136.

## COMPONENT LEVEL APPLICATION OF THE MAN-MACHINE SYSTEMS METHODOLOGY

The Component Level application of the Methodology to the photo-receptor cells could be delineated at this point utilizing the physiological background that has been presented. However, even before beginning this task it may be recognized that there are essential areas that have not been investigated.

One of the most prominent problems that has been left unanswered concerns frequency detection within the rods. This brings up the general question of the mechanism of color vision. Does the photo-receptor cell carry out the major portion of the color vision process? Is an understanding of the chemicals within the photo-receptors the key to an explanation of color vision?

The answers to these questions require research into the fundamentals of color vision. To date, physiological research has not examined the basic mechanisms of color vision, but has promulgated the so-called "three color theory". This theory assumes that there are three types of photo-receptors in the eye that are each sensitive to a different portion of the visible spectrum. When the three work in combination, enough information is provided to the brain to convey the shade of any color.

As a starting point in answering some of these questions, the phenomenon discovered by Edwin H. Land of the Polaroid Land Camera Corporation will be studied. Land demonstrated that color could be produced from two black and white positive transparencies, one that was projected through a red filter and the other with white light. This was a demonstration that two colors can be used to produce (at least subjectively) the entire visible spectrum. This problem will be investigated by Teledyne, and some results will be given in the final report under this contract.

## CONCLUSIONS

Research into the operation of the visual sensor has developed the initial human analog of the eye. The human analog has been constructed by filling out a group of tabular forms for each Methodological aspect. This method of developing the human analog has proved to have a number of desirable features. Tabular format has allowed a non-linear system such as the eye to be described. Lack of applicable differential equations that could be used to construct a human analog has not been an obstacle. Every piece of data that was produced was found to have a specific place on the Information Sheets.

Comparing the human analog that this report has produced to previous efforts at describing the operation of the eye, the merits of the present approach may be realized. Prior physiological investigation approached the eye by dissecting it into arbitrary anatomical parts and then analyzing the function of each of these pieces. No consideration was given to how the function of a small part contributed to the operation of the entire eye. An example of this concern with detail is the concentration on each of the types of cells within the cornea while ignoring their contribution to the visual process. Table I in the section "Component Level Examination of the Operation of the Human Eye" lists thirteen cornea components that are separately analyzed in ocular anatomy. As this table indicates, the eye has been divided into dozens of cellular components by the anatomists, and as a result, investigators that have studied functional relationships of a few of these parts have not produced basic insights into the visual process.

In the research that has been conducted, attention was directed toward keeping extraneous details out while striving to utilize information that would illuminate the visual process. The entire Subsystem investigation was carried out in a framework that oriented data toward a clearer understanding of the human eye. Each intersection of the Subsystem Matrix considered provided a description of another facet of the operation of the entire eye. For all of the intersections discussed, information was directed toward explaining the overall subsystem and not in developing relationships between the various facets. Anatomical data has been primarily grouped under the heading Configuration Information and has thus been separated in each file.

One of the guiding principles that was utilized by the Function Influencing Factor was to trace the information signal. Each of the aspects considered under Function presented a description of this signal during a specific phase. A basic question was answered when a description of how the eye detects the information signal was given. As this signal was traced, a clear idea of the form of the information envelope was obtained. For example, the information signal was in the form of transverse ion flow within the neurons of the retina. The composition of the signal as well as the energy conversions undergone were described. Concentration on tracing the information signal has produced a human analog that has described the basic processes of the eye. The Man-Machine Methodology has suggested that a guide to all scientific investigation concerned with probing functional operation is to trace the flow of the information signal.

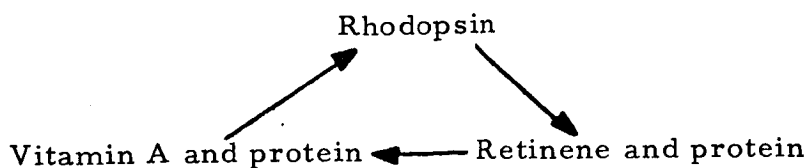
During the collection of data on the photochemical reactions that take place within the rods and cones (photoreceptors), it was found that the literature described various chemicals. Many of these chemicals have not been found in the eye, but were discussed because they can react to form

compounds that have been located in the photoreceptors. In order to produce some desired reactions, these "selected" chemicals were heated to temperatures considerably above that found in the rods for periods of many minutes. Frequently these reactions were repeated, each time at a different pH. Here again the laboratory experimentation was performed without consideration of the pH changes within the photoreceptors.

There is a lesson to be learned from these observations. When studying the photoreceptors, the primary concern should be with the chemicals within these cells. The environment of the chemicals should be kept in mind while relating all experimental parameters to the known conditions in the photoreceptors.

Perhaps some of the misdirection discussed above is responsible for the lack of insight into the visual pigment (rhodopsin) contained within the rods. As was mentioned in the section "Outline of the Photoreceptor Processes", the ratio of the number of molecules of chromophore to that of protein is not accurately known, and these are the only two constituents of rhodopsin.

The present day literature describing the physiology of the eye contains many references to a rhodopsin cycle (shown below) that was developed prior to 1940.



This has become the classic cycle. But it is incorrect as indicated by the explanations of the breakdown and resynthesis of rhodopsin that are given in these same books. A new cycle was developed, while constructing the scheme shown in Table I of the section "Outline of Photoreceptor Processes." A number of previously unrelated facts were used to correct and update the classic rhodopsin cycle.

If scientific researchers would utilize the Man-Machine Methodology, data that is related would be brought together. The Methodological framework represents an excellent structure to store all pertinent information. Prior to applying the Methodology, it will be necessary to gain a general familiarity with the subject. This has been illustrated in the present report by the inclusion of the sections that give physiological outlines of the operation of the eye and the photoreceptor processes.

The Methodological approach has led to the disclosure of areas in which basic research is needed. In the investigation of the Functional Aspect of Detect (File No. 4-79-01), it was found that the literature did not contain an explanation for this function. Thus one area in which research would be profitable is to study how a structure, such as the eye, detects visible radiation. This research could produce results that would apply to the detection of the entire electromagnetic spectrum.

In order to explain how the eye detected and absorbed visible radiation, a hypothesis was proposed in File No. 4-79-01. This hypothesis was based on the phenomenon of resonance. It was assumed that there were resonant structures within the eye that responded to the frequencies of visible radiation. Physiological evidence suggested that these structures were located in the rods and cones. When electromagnetic radiation in the visible spectrum impinged upon the photoreceptors, the latent ability of these structures was utilized and resonance occurred.

The initiation of resonance was considered to constitute the detection function while the actual dislocation of particles was described under the aspect of quantize (File No. 4-80-01). Quantization was hypothesized to commence after the completion of detection. When energy absorption by the resonating structures reached a specific level, electrons were freed from their bonds and moved from the photoreceptor surface into the receptor proper. The energy of the electrons was in proportion to the activity of the visible radiation that was absorbed by the resonant structure.

With the hypothesis above in mind, the investigation of the photoreceptors at the Component Level was begun. A description of the previously hypothesized resonant structures within the photoreceptors was found. These structures are called  $\pi$ -orbitals and are constructed by the excess electrons that remain after covalent bonds have been formed between the two molecules that compose rhodopsin.

The reported existence of these structures helps to substantiate the resonance hypothesis. Another confirming factor is an explanation of how the resonance process takes place by H. J. A. Dartnall in his book The Visual Pigments, page 133. Dartnall explains that the oscillation of impinging radiation causes the structures with the latent ability to resonate to move back and forth along the conjugated chain, congregating alternately at each end. Only light that is of a frequency that can resonate with the rhythmically oscillating  $\pi$ -orbitals will be strongly absorbed.

Development of the resonance hypothesis, that has been described above, has applications that are much wider than only explaining how the photoreceptors detect visible radiation. The entire electromagnetic frequency range is encompassed by this hypothesis because all energies in this spectrum are absorbed in a similar manner. Basic research that would establish or modify this hypothesis could produce a new fundamental physical law.

Investigation of the functional aspect called Qualify (File No. 4-81-01) led to the disclosure of another area in which research is needed. When the question of how the eye determines what frequencies are impinging on the photoreceptors was encountered, it was found that an understanding of color vision was required. Examination of color vision properly should take place at the Component Level and thus the Qualification aspect did not discuss this topic.

Teledyne Systems Corporation will investigate color vision and attempt to assess if three photopigments are actually required. In an article published in "Scientific American," May 1959, Edwin H. Land described how two colors could be used to produce the sensation of the full spectrum. Perhaps the eye in conjunction with the brain can produce all of the colors using only two photochemicals in the retina. This study will try to find answers to a number of questions raised by Land's article as well as attempting to suggest a valid approach to a three color theory of vision.

The human analog was written in the terminology of the Man-Machine Methodology and thus can be directly applied to the design of machine extenders. Useful machine extenders can be derived from the human analog in a much more straightforward fashion than from a physiological explanation of the operation of the eye. Since the human analog has been organized according to the influencing factors of the Methodology, design information may be easily located under the appropriate factor of environment, function, configuration or material.

Deriving machine extenders from a human analog has the advantage that there is no technical language barrier to hamper the retrieval of information from the Methodological forms. Terminology used in developing the human analog is common to all fields of science and thus a physiologist, who may gather information for the Methodological forms, can easily be understood by an engineer, who may be designing a visual extender. After the designer of machine extenders has become familiar with the applicable data contained in the human analog, he can directly apply this information in the implementation of the device.

By using the human analog of the eye, design criteria for machine extenders may be developed that are considerably more sophisticated than presently available. Today there are machine extenders that are based on the most obvious principles of operation of the visual sensor. Enormous optical telescopes have been constructed that simply act as enlarged retinal surfaces in gathering light. For viewing small objects, microscopes have been constructed with components that magnify the image as is the function of the crystalline lens of the eye.

A number of the statements made in the preceeding paragraphs may be clarified by tracing through a design example. Consider the design of a device that would enable the eye to operate in a environment of much lower light intensity than the unaided visual sensor. First information under the functional aspect of qualify should be reviewed. Here a discussion of how the eye attenuates the intensity as a function of frequency will be found.

At the Subsystem Level the aspect of qualify (File No. 4-80-01) dealt with the entire eye and did not discuss how the individual components attenuated the intensity. Each of the components that filter light should be individually investigated in order to establish how much the entering light is attenuated as

it passes through each part of the eye. Such a study will reveal those frequencies that would be most desirable to utilize for optimum performance of the rods under low light level conditions.

Now a machine extender could be designed that modifies the light before it enters the eye. The device would transmit the information signal to the visual sensor on the selected frequencies. It is true that such a device would not present a normal frequency spectrum to the eye, but this is not grounds to conclude that the colors transmitted by the device and interpreted by the brain would be different from those reflected directly from the object. The study that Teledyne Systems Corporation is currently engaged in may enable such a device to be designed so that the apparent colors were not altered. This study could establish some new concepts in the understanding of color vision.

After an understanding of the human analog of the eye has been accomplished, machines can be designed that work on the same principles as those used by the visual sensor. Such machines would have advantages over presently available devices. These new machines could operate at low frequencies after detecting the information signal as is the case in the eye. Rather accurate spacial relationships could be transmitted with building blocks that are similar to the neurons in the retina.

Research into the human analog of the eye has proved fruitful in many ways. As the first detailed application of the Man-Machine Methodology at the Subsystem Level, this report serves as a model for future research. The human analog has located some areas that could profit greatly by physiological investigation. It was found that studies of the eye could produce more insight to the visual process by following the format of the human analog. Many scientific researchers in diverse fields of study can profit by a close examination of the human analog of the eye.

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## APPENDIX A

## SUMMARY EXPLANATION OF THE MAN-MACHINE SYSTEMS METHODOLOGY

The Methodology is based on a hierarchy of levels that succeedingly become more detailed. In order to completely analyze a problem, the Methodology must be traced to the most basic level, but it may not be necessary to begin at the most general level, i.e., investigation of the visual sensor began on the subsystem level. For convenience the levels have been given decimal numbers. Table A shows the numbering of the levels beginning with the most general.

<u>Number</u>	<u>Le vel</u>
1	Mission
2	System Complex
3	System
4	Subsystems
5	Component
6	Chemical
7	Physics

Number of Levels

Table A

These levels are divided into elements which are listed by columns on all Methodology matrix charts, Tables B through F. Each element has a decimal identification number. Examples of this numbering code may be seen on the matrix charts, Tables E and F.

The charts show the breakdown of each level into the following four influencing factors: environment, function, configuration, and material. Each influencing factor is broken into various aspects that are listed as separate rows on the charts. Again the aspects are decimally numbered to facilitate identification of a row or an intersection.

For ease of reference, any intersection on one of the matrix charts can be identified by a coded number. Every coded number has three parts, each separated by means







[illegible]

SUBSYSTEM MATRIX CHART ENVIRONMENT

Table E.



of dashes. First the level is given as shown on Table A; then, the row is called out, and finally the column is identified. An example of a coded number is 4-22-13. Four calls out the subsystem level matrix chart while 22 is the aspect called force, pressure and 13 is the man, output, musculo-skeletal column.

There is a form for each of the influencing factors that is called an information sheet. These forms are used to describe an influencing factor. In order to complete the description, supplemental information sheets may have to be filled out under the heading of an influencing factor. Thus, the same form may be used for more than one factor and the information contained will be different. Table G gives the organization and methodology order of the information sheets for all levels.

Primary Influencing Factors	Supplementary Sheets	Information Content
Environment		Environment of entire object
	Function	Function of entire object in a given environment
	Configuration	Configuration of materials that are affected by environment
	Materials	Materials of object that are affected by the environment
Function		Function examined by aspect for a given environment
	Configuration	Configuration of materials that are concerned with performing the function
	Materials	Materials that are concerned with performing the function
Configuration		Configuration of materials that compose of the entire object
	Materials	Materials of entire object grouped according to configuration breakdown
Materials		Materials that compose the entire object grouped by materials breakdown

#### Organization of Information Sheets

Table G

### Information Sheets

Application of the Man-Machine Systems Methodology entails the filling out of the information sheets that are listed on Table G. This table indicates each of the four influencing factors and their associated supplementary sheets. The ordering of the forms shown on Table G will be followed in assembling the information sheets. A general statement of the content of each sheet is given on the following pages.

## Environment Information Sheet

On the environment information sheet, all the parameters required to describe the environment are listed, and data pertaining to each are given.

On the following page is a blank environment information sheet that may be referred to in locating the terms that are defined below.

<u>Term</u>	<u>Definition</u>
Element	Column heading
Parameter	Manifestation of energy of the object
Quantity	Amount/some selected unit volume
Rate of Normal Incidence	Number of exposures/unit time
Rate of Change	Rate of change over a selected time interval
Amt	Amount
Dur	Duration

Definition of Terms on Environment Information Sheet

Table H

# ENVIRONMENT INFORMATION

FILE NO :		ELEMENT:		UNIT OF RATE OF CHANGE:														
DEFINITION ENVIRONMENT PARAMETER	QUANTITY												RATE OF CHANGE					
	NORMAL			MINIMUM			MAXIMUM			RATE OF NORMAL INCIDENCE			NORMAL		MINIMUM		MAXIMUM	
	AMT	DUR		AMT	DUR		AMT	DUR		AMT	DUR		AMT	DUR	AMT	DUR	AMT	DUR
EARTH																		
LUNAR																		
SPACE																		
PLANETARY																		

## Function Information Sheet

The Function Information sheet has many columns to describe an object and how it is modified. This description has a number of limitations. The first stems from the division into input, distribution and control and output. Each of the functional aspects falls within one of these divisions. The functional aspects at the subsystem level are listed on Table F. They are the rows numbered from 78 - 109. The eye, which is a subsystem, is also divided into input, distribution and control output. When discussing a specific functional aspect, only that portion of the eye that is within the same division (input, distribution and control and output) may be included. As an example, under the functional aspect of transmit decoded signal (4-95-01, Table F), only the signal that is leaving the distribution and control portion of the eye can be discussed.

A second limitation on the function information sheets is concerned with the level of examination. If a problem is being examined on a specific level, then information on the function sheet can only refer to details that are on the next lower level; for example, a function sheet on the subsystem level can explain phenomena with details from the component level. This means that on the subsystem level explanations cannot include statements of how specific chemicals or atoms interact.

In some cases, a hypothesis may be proposed to explain a functional aspect. For this aspect, explanations may include mention of phenomena that take place more than one level down, but these interactions may only be located within a component that is one level down. An example to illustrate this situation may be found by considering a hypothesis to be proposed on the subsystem level. The hypothesis may discuss atomic interactions, but the specific atoms may only be located within the components and not within chemicals that compose the components.

The outputs of components, regardless if they are subatomic particles, atoms or chemicals, can be discussed at any level since they are not internal to the components. This concern with the materials from specific levels that may be discussed on function information sheets stems from rules of the methodology. These rules control the organization of data and require concentration on each level as it is

encountered while putting off consideration of more detailed information. Thus, it will be found that at the higher levels, many of the columns on the function sheets will be blank because the information needed cannot be included at that level.

At every level, the entity under consideration is divided into its functional segments. These segments include the input, distribution and control and output. The physical boundaries of these segments are not critical since any details that are not encountered at one level will be met at a lower level. As an example, consider that the iris and lens are in the input portion of the eye. Both of these components accept an internal control signal that stimulates their muscles, but this functional aspect is listed in the distribution and control portion of the eye. Therefore, these components will not be discussed under accept internal control signal. When the iris and lens are investigated on the component level, the internal control signal will be described.

On the following page is a blank function information sheet that may be referred to in locating the terms that are defined below.

<u>Term</u>	<u>Definition</u>
Element	Column heading
Aspect	Row heading
Object	Totality that brings energy in
Parameter	Manifestation of energy of the object
Characteristic	Dynamics of property
Convert to	New energy form of the object
Method	Way in which unit of the environment is classified
Method Sub-Detail No. 1	Way in which unit of the environment is classified - next lower level
Mechanism	Dynamic means of conversion
Operation	Way in which the mechanism operates
Operation Sub-Detail No. 1	Way in which the mechanism operates - next lower level
Change when Tolerable Limits are Exceeded	Change in parameter that modifies the function

Definition of Terms on Function Information Sheet

Table K

# FUNCTION INFORMATION

FILE NO:		ELEMENT:											
<div>DEFINITION</div> <div>FUNCTION</div>	OBJECT	PARAMETER	PROPERTY	CHARACTERISTIC	CONVERT TO	METHOD	METHOD SUB-DETAIL NO.1	METHOD SUB-DETAIL NO.2	MECHANISM	OPERATION	OPERATION SUB-DETAIL NO.1	OPERATION SUB-DETAIL NO.2	CHANGE WHEN TOLERABLE LIMITS ARE EXCEEDED
	ASPECT:												

TSC1642

FUNCTION INFORMATION SHEET  
Table L

• Configuration Information Sheet

Under the configuration information sheet are found drawings and numerical data. Every component that is identified on a configuration drawing is of importance in relation to the influencing factor under consideration. Headings on drawings first list a descriptive title, then an anatomical description of the illustration and finally the influencing factor.

Below, the definitions for the terms on the configuration information sheet are given and on the following page a blank form will be found to aid in locating these terms.

<u>Term</u>	<u>Description</u>
Element	Column heading
Aspect	Row heading
Arrangement of Parts	Drawing
Connection of Parts	Drawing
Dimensions	On drawing
Shape	Drawing
Motion	Drawing
Degrees of freedom	Three numbers for location and three numbers to describe motion
Environment Interface In	Drawing
Environment Interface Out	Drawing
Change when Tolerable Limits are Exceeded	Point where configuration is permanently changed

Defintion of Terms on Configuration Information Sheet

Table M

## CONFIGURATION INFORMATION

[illegible]

**TSC 1641**

**Configuration Information Sheet, Table N**



## Material Information Sheet

The material information sheet lists the materials that compose the next lower level; for example, the materials on the subsystems level are composed of the components.

Below are defined the terms on the material information sheet. On the next page, a blank sheet is presented to aid in the location of the terms that are defined below.

<u>Term</u>	<u>Description</u>
Element	Column Heading
Type	Row Heading
Existence	Statement that the occurrence of material is known or unknown
Availability	Scarcity or plentifulness of material
Producibility	Ease or difficulty of manufacture
Relative Cost	Value, worth

Defintion of Terms on Material Information Sheet

Table P